THE AUGUST SCIENTIFIC MONTHLY

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THE SCIENTIFIC MONTHLY

AUGUST, 1934

CHILD DEVELOPMENT FROM THE STANDPOINT OF GENETICS

By Dr. CHAS. B. DAVENPORT

DIRECTOR, DEPARTMENT OF GENETICS, CARNEGIE INSTITUTION OF WASHINGTON

I

THE development of a child begins with a fertilized egg. This is the common view: but actually the beginnings were laid millions of years ago. Unless we approach the problem of development from this standpoint it is comparatively meaningless.

The egg at the moment of fertilization is a minute sphere (Fig. 1), about $\frac{1}{8}$ of a millimeter (1–200th of an inch) in diameter. It shows a rather dense body of food (yolk) granules. It contains a large sphere—the nucleus (Fig. 2). There is doubtless some water present, as in other eggs, possibly about 50 per cent. of the total weight. All the cell body outside the nucleus is called cell protoplasm or cytoplasm.

The nucleus is a fluid-filled sphere in which float threads (perhaps a foamwork), in which lie minute organic particles that come together from time to time to form elongated bodies that are called chromosomes. In the child there are in each cell twenty-four pairs of these chromosomes. In each division of the cell each of these chromosomes splits (Fig. 3) into two identically similar chromosomes, of which one goes to one of the daughter cells and the other goes to the other. It is by this means that each cell, certainly at the beginning, receives a full complement of chromosomes.

Development begins by division of the fertilized egg and nucleus into two cells; these divide again, making four; these divide again, making eight, and so on. If the derived cells were each to divide into two repeatedly for as many as forty-five generations there would be produced more than the twenty-six trillion cells which are believed to make up the human body. However, this possibility is actually not realized. Some of the descendant cells slow up very greatly their division; others may go on to many more cell generations.

FIG. 1. A HUMAN EGG

FOCUSED JUST BENEATH THE SURFACE SHOWING THE YELLOW YOLK GRANULES ABOUT IN FOCUS AND THE MOSAIC OF WHITE YOLK SPHERES (W. H. LEWIS, 1931).

But not all growth takes place by cell division. A second no less important process is expansion by imbibition of water. After a spherical mass of cells has been produced, a hollow sphere arises of which the wall is made up of these cells (Fig. 4). The hollow sphere contains water which has passed from the medium in which the cell floats through the wall into the center of the sphere. Thereafter, and progressively more and more, the embryo consists of membranes and cell masses which are separated from each other by a large volume of water. Of the young embryo 96 to 98 per cent. may be water. This separation of the different membranes and cell masses gives room for them to fold, and the fluid provides a medium in which the migrating cells of the embryo can travel from place to place inside to the embryonic body (Fig. 5).

A third process in development now becomes more prominent. The cells become different in the act of forming diverse organs and tissues. This process is called *differentiation*. Very early, through a rapid multiplication of cells in one area of the egg, one can locate the point at which the future fetus is to develop rapidly (Fig. 6), and first to appear is the longitudinal axis of the future child. This line, which we may see upon the dense cell area, is the line of its spine. Along this line, cells roll from the outer membrane into the interior to form a long *pocket*, and eventually a long *tube*. This is the beginning of the food canal (Fig. 7). Immediately following the formation of the food

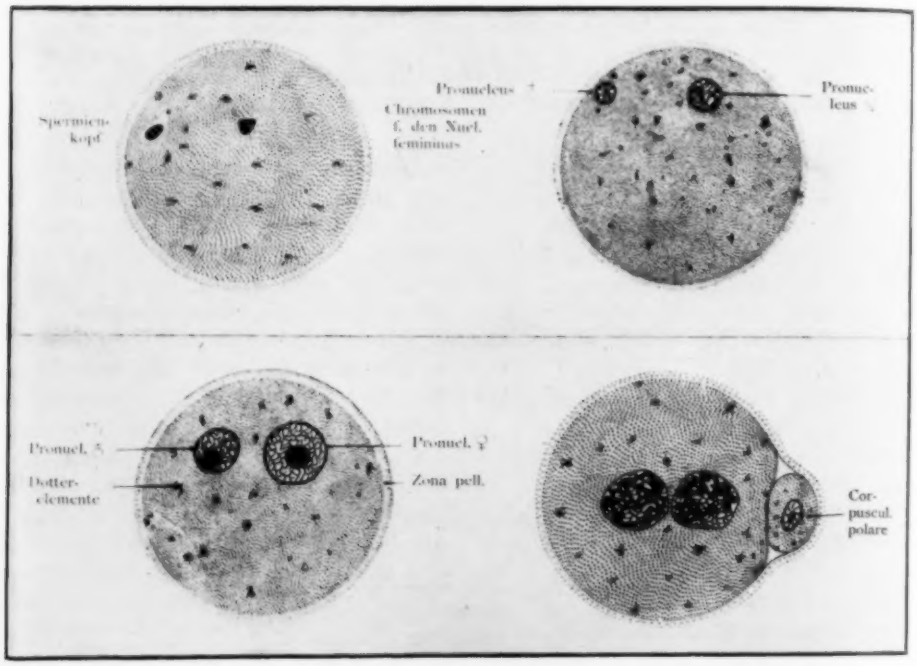

FIG. 2. MOUSE EGG

UPPER LEFT, SPERM HEAD AND FEMALE PRONUCLEI; UPPER RIGHT, MALE AND FEMALE PRONUCLEI; LOWER LEFT, MALE AND FEMALE PRONUCLEI FURTHER DEVELOPED; LOWER RIGHT, MALE AND FEMALE PRONUCLEI COMING TOGETHER, CHROMOSOMES FORMED, POLAR BODIES EXTRUDED (KOLLMANN, 1907).

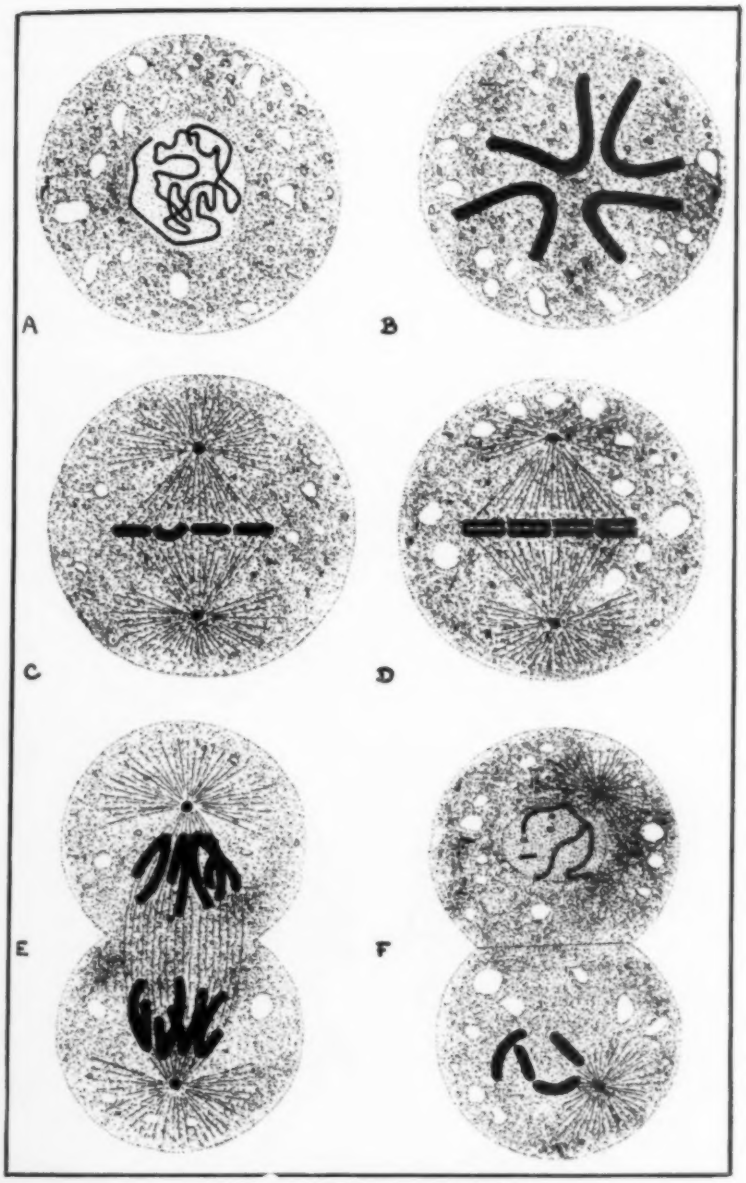

FIG. 3. SHOWING CHANGES

THROUGH WHICH THE CHROMOSOMES OF ASCARIS, A PARASITIC THREAD WORM, PASS WHEN CELL DIVISION TAKES PLACE. DRAWINGS OF ACTUAL SPECIMENS CUT IN THIN SECTIONS. A, EARLY STAGE, CHROMATIN THREAD SLIGHTLY CONDENSED; B, CHROMATIN THREAD HAS FORMED INTO CHROMOSOMES WHICH ARE ARRANGED ACROSS THE MIDDLE OF THE SPINDLE; C, SAME AS PRECEDING, VIEWED FROM THE SIDE OF THE SPINDLE, WITH CHROMOSOMES NOT COMPLETELY IN THE SECTION; D, CHROMOSOMES SPLIT LENGTHWISE; E, CHROMOSOME HALVES MOVING APART, CELL BODY BEGINNING TO DIVIDE; F, DIVISION OF CELL BODY COMPLETE, CHROMOSOMES IN CELL AT TOP BEING RECONSTRUCTED INTO A NUCLEUS (A. FRANKLIN SHULL).

canal there is established the beginning of the spinal axis, and on top of that the beginning of the brain and spinal cord.

Along this axis, multiplication of cells takes place most rapidly at one end, which we soon recognize as the head end

verse furrows. These correspond in position to the gill-slits of the embryo fishes. The grooves never become real slits. They do not permit the water to pass by the bars, as in fishes. But these bars play an essential rôle, nevertheless,

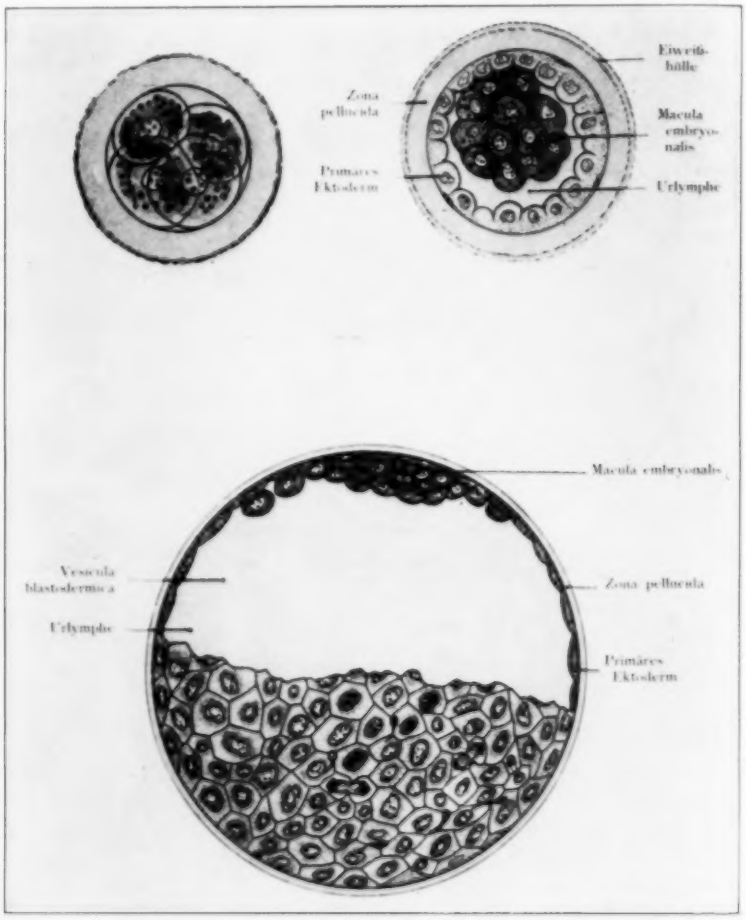

FIG. 4. MAMMALIAN EGGS IN EARLY DEVELOPMENT

UPPER LEFT, BAT EGG IN STAGE OF FOUR CLEAVAGE SPHERES; UPPER RIGHT, EGG OF RABBIT, FORMATION OF BLASTODERM, OR EMBRYO PROPER. LOWER RABBIT IMBIBED WATER DIVIDES THE BLASTODERM ABOVE, FROM THE TROPHOBLAST BELOW (KOLLMANN, 1907).

(Fig. 8). In it appears the large brain. On each side, the large eyes, nasal pit and mouth are beginning to make their appearance. Behind the head is a long region which represents the embryonic neck. On each side is a series of trans-

because from them are budded the thyroid gland and the tonsils.

From the last of the bars arises the hyoid bone of man, which supports the tongue, and out of one of the potential gill-slits arises the Eustachian tube

which passes from the throat by the ear capsule and would open to the exterior of the outer ear were it not for the tympanic membrane that prevents. In these gill-bars are blood vessels which, being no longer required for aquatic respiration, as in fishes, take on another function and go to the lungs instead of the gills. Others supply the brain with nourishment. As soon as these organs are formed, the grooves on the neck flatten out, for, since gills are not required, they have no further function.

Behind the neck the trunk (Fig. 9) is seen as a tubular body, from near the center of which there passes out a cord through which the nutritive fluids pass from mother to child and the waste products are returned from the child to the mother. Already in this trunk we may see the rings or segments of which the body is composed, which correspond in position to the series of ribs attached to the different trunk vertebrae. Finally, behind the trunk, there appears a small

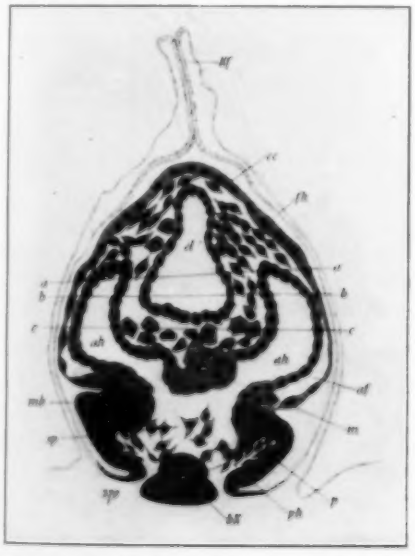

FIG. 5. CROSS SECTIONS OF EMBRYO OF THE TUNICATE SALPA

SHOWING THE RÔLE OF SPACES AND FOLDINGS OF MEMBRANE AND MIGRATORY CELLS IN DEVELOPMENT.

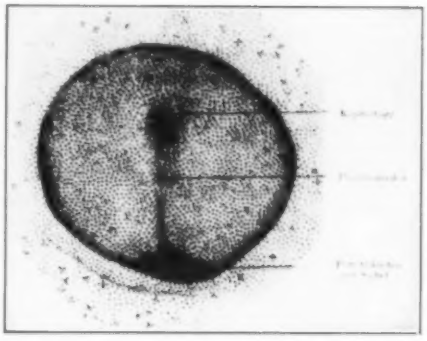

FIG. 6. EMBRYO OF THE DOG

SHOWING EMBRYONIC SHIELD WITH THE AXES OF THE FUTURE EMBRYO IN THE MIDDLE LINE AND THE THICKENING ABOVE TO FORM THE HEAD. THE FURROW WILL FORM THE NEURO TUBE. THE CELLS FROM THE MUSCLES AND HEART ARISE AND ARE BEGINNING TO FORM (KOLLMANN, 1907).

elongated appendage which carries the spine (or its forerunner) nearly to its tip. This represents the tail of fishes and of the lower vertebrates.

The next stage shows that great changes have taken place. The head has become enormously enlarged and from the swollen trunk there arises on each side a pair of flat buds, the beginnings of the four appendages. On each appendage there arise three main segments. On the furthermost segment five lobes form, each one of which eventually represents a finger or toe. The tail gradually becomes resorbed (Fig. 10), as in birds, guinea pigs and apes, until nothing remains of it except a small appendage at the end of the spinal column.

Meanwhile the internal organs are differentiating. From the primitive gut arise lungs, liver, pancreas and other organs. Independently arise the urogenital organs. The skin becomes differentiated. The mouth lining forms tongue and teeth; the skin forms glands, nails and hair. The internal skeleton and muscles become even more complex and mature, and the head and the appendages become mobile. Usually soon

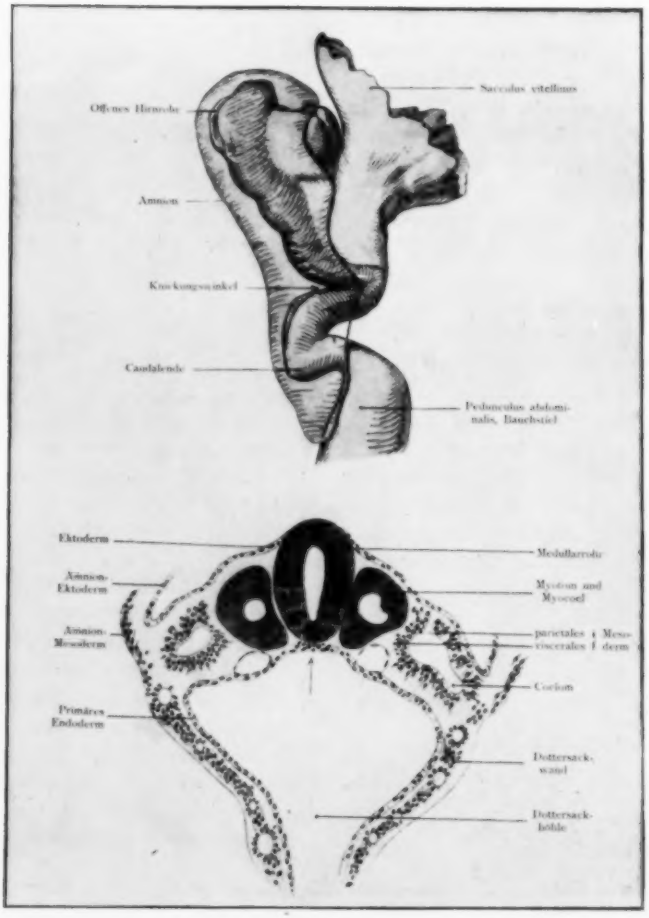

FIG. 7. HUMAN EMBRYO

ABOVE, THE EMBRYO ALREADY SHOWS THE ENLARGED HEAD, HAS A TEMPORARY KINK IN THE BACK. BELOW, CROSS SECTION OF HUMAN EMBRYO AT THE SAME STAGE, SHOWING ABOVE THE NERVE CORD, BELOW THE DEPRESSION IN WHICH THE SPINAL COLUMN WILL ARISE, ON EACH SIDE THE BEGINNINGS OF THE MUSCLE MASSES; AT THE BOTTOM THE FOOD CANAL. (KOLLMANN, 1907).

after birth dark pigment appears; the hair becomes brown or red; the iris, at first blue, may develop a brown coat. The child's mental life develops hand in hand with its nervous system.

To recapitulate: The minute egg forms a germinal disk. Along its axis a fish-like embryo arises; soon this gains the large head and brain and the two pairs of lateral appendages characteristic of the human child. Specialization of parts is completed.

II

Now that we have followed the developing child through the intrauterine period, we return to a consideration of the factors that are operating to produce a child. It is obvious that the form changes which the child experiences are chiefly determined by factors inside the developing organism. It is hardly necessary to say that appropriate external conditions are required; that nutriment must be provided.

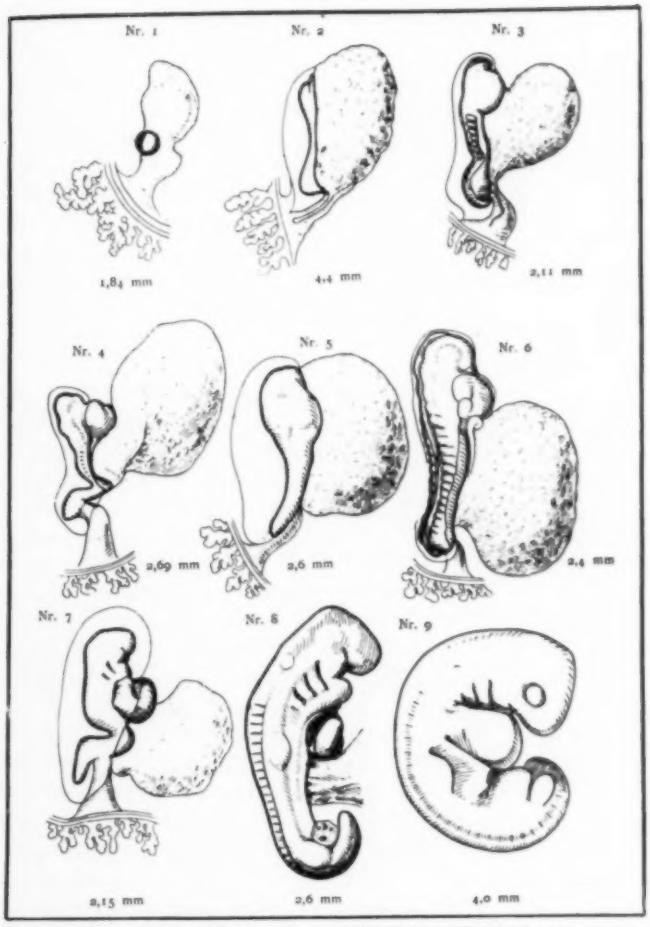

FIG. 8. SUMMARY OF THE EARLY DEVELOPMENTAL STAGES OF THE HUMAN EMBRYO

1, THE EGG IS ATTACHED TO THE MATERNAL TISSUES; 2, THE EMBRYONIC SHIELD IS ELONGATING; 3, MUSCLE MASSES BEGIN TO SHOW AS A SERIES OF COMPRESSED SPHERES ON EACH SIDE; 4, STAGE WITH TEMPORARY KINK; 5, THE KINK IS STRAIGHTENED OUT, THE HEAD IS ENLARGED; 6, SEGMENTATION OF THE TRUNK APPEARS; 7, 8, 9, THE EMBRYO WITH GILL-SLITS AND THE BEGINNINGS OF THE FORMATION OF APPENDAGES.

These are indeed obvious. But given the necessary conditions for development, even including a considerable range of variation in those conditions, the human embryo will proceed along its path to produce a child.

What do we know of these internal facts which direct this development? Philosophers from the time of Aristotle have realized that there must be agents inside of the egg and developing embryo which are directing its course, and these have for three quarters of a century been known as some sort of "genes." It is, however, only during the present century that the philosopher's units have become identified with objects that can be experimented with and whose work can be intimately followed.

Without going into all the evidence that the genes that lie in the chromosomes are largely responsible for direct-

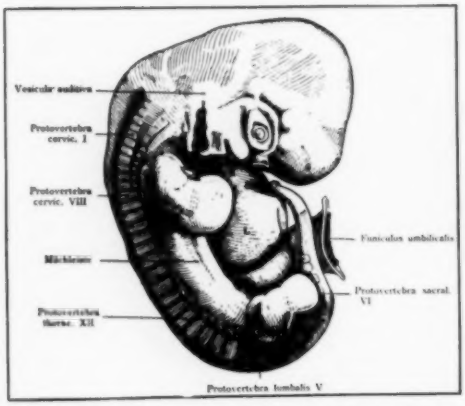

FIG. 9. THE STAGE SHOWING THE BEGINNINGS OF THE VERTEBRAL COLUMN AND THE LONG TAIL (KOLLMANN, 1907).

ing development, I call your attention to some figures by the late Dr. John Belling, which show, perhaps in more or less diagrammatic form, the genes or group of genelets as they lie at the center of a row of spheres, strung along threads (Fig. 11). These collectively constitute the essential part of the chromosomes. These genes are probably large molecules of complicated structure, with a molecular weight of 50,000 more or less, the molecular weight of hydrogen being 1.

They probably are enzymes. Enzymes, I may remind you, are organic chemical substances that belong to the group of catalysts. And catalysts have the remarkable property of accelerating

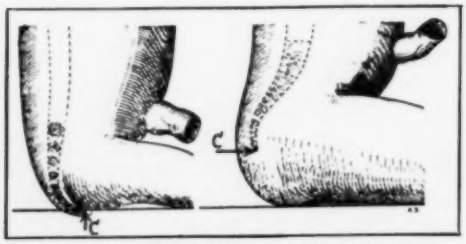

FIG. 10. DIAGRAMMATIC REPRESENTATION OF THE TIP OF COCCYX IN RELATION TO THE LEVEL OF THE BUTTOCKS. HUMAN FETUS OF TEN WEEKS ON THE LEFT, HUMAN NEWBORN ON THE RIGHT (A. H. SCHULTZ).

chemical processes without themselves being changed or used up in these processes. Enzymes then may be said to be activators of chemical reactions in living cells. Every person who bakes bread makes use of the enzymes of yeast to accelerate the reactions in flour. All fermentation as of cider or wine is due to enzymes.

The genes have each, apparently, the unique property of divisibility into two molecule-groups, like the one from which they are derived. This process is capable of indefinite repetition by which, in the course of time, the descendants of any one gene may become incalculably numerous. The genes in the nucleus are ordinarily two of a kind—paired (one element of each pair having come from the sperm, the other from the egg). The number of kinds of these genes in an individual child is very great, probably thousands. The different gene-pairs play each a different but essential rôle in the cell.

That the genes have different specific rôles to play as directors of development, as well as certain general ones, has been demonstrated, especially by the study of the vinegar fly, Drosophila. Here, some genes are responsible, among other things, for coloration in the eye, others for the form of wings, others for the determination of sex, and so on. In man, no such analysis has been possible as in the vinegar fly. This is partly because the human generation is thirty years, while that of the vinegar fly is less than 30 days; partly because there are twenty-four pairs of chromosomes in man and only four in the fly.

Accepting, as demonstrated, the theory that the genes are the directors of development, the great problem before geneticists to-day is, how do they do their work? To this question we turn our attention. Although the end result is complex the means by which the genes do their work may be relatively simple. Examples follow:

Cell division: It has been shown by Hammett that this can be accelerated by the sulfhydryl group (–SH), and this group is frequently found in the protein molecule. If there are genes that promote cell division, it is probable that they activate some sulfur compounds, as a first step in the process.

Imbibition of water: Many colloids (*i.e.*, non-crystalline substances like white of egg), such as are found in embryonic cells, are lyophilic (dilute-solution lovers) and may imbibe great quantities of water with change of acidity. Body spaces and probably most membrane *foldings* are produced in this way. One face of a membrane swells over a limited area, and that face becomes convex toward the cavity into which it folds.

Differentiation: Soon after development begins the cells come to have dissimilar contents and form. Special chemical changes are taking place in each. Eventually, special tissues—muscle, nerve, cartilage and others—arise. It has long been known that some of the changes are due to enzymes in the cells. For example, to form the black pigment that is found in hair and iris, and the skin of Negroes, there is present the enzyme called *tyrosinase*. This promotes the oxidation of wide-spread *tyrosin*, which then becomes black. In the absence of tyrosinase in the cells, albinism results. By genetic analysis albinism is due to the change of a single gene and is thus definitely inherited.

Again, it is known that fibrin of the blood is formed in the presence of an enzyme *thrombase* which hydrolyzes (or subtracts water from) fibrinogen. If this enzyme is not found, fibrinogen is absent in the blood in sufficient quantity to permit it to clot. Persons whose blood fails to clot are hæmophiliacs, or bleeders, like the late Tsarovitch of Russia. And genetic analysis shows that this condition is due to a change in a gene that is located in the sex chromosome.

In many plants with highly colored flowers the color is due to an oxidizing enzyme, called *anthocyan*, which acts upon a plant sugar (glucoside) to make red, blue and violet pigment. The brilliant colors of our flowers, our foliage plants and autumn landscapes (Gortner) we owe to these anthocyanins.

These are examples merely to show the great effects resulting from specific gene-enzymes. The ultramicroscopic gene is able to perform such large results by virtue of the catalytic quality of enzymes. These enzymes, indeed, have

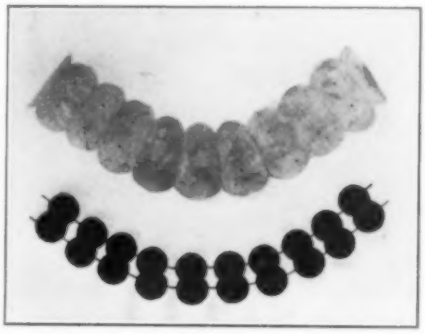

FIG. 11. UPPER, DOUBLE ROW OF CHROMOMERES

IN THE POLLEN MOTHER-CELLS OF ALLIUM (THE ONION FAMILY) AS SEEN UNDER THE MICROSCOPE, GREATLY ENLARGED. THE CHROMOMERES HAVE BEEN SQUEEZED FLAT SHOWING THAT THERE IS AN EXTREMELY MINUTE GENE IN EACH. LOWER, A DRAWING REPRESENTING THE ABOVE DOUBLE STRING OF DEEPLY STRAINED CHROMOMERES BEFORE DESTAINING AND SQUEEZING FLAT.

extraordinary properties, as just indicated. Their action is intense, markedly specific and intimately dependent upon environmental conditions of temperature, acidity, etc. As an example of catalytic action of an enzyme: A peroxidase may activate 1,000 times its weight of H_2O_2 (hydrogen peroxide) per second at 20° C. (Haldane).

Examples of the rôle of enzymes in development might be multiplied indefinitely. We are brought to the conclu-

FIG. 12. FLEXED TAIL MOUSE
MIDDLE FIGURE SHOWS SHORTENING OF THE TAIL AND TENDENCY TO FORM A SPIRAL AT ITS BASE (H. R. HUNT).

sion that enzyme action is an important key to differentiation.

What is known about the source of enzymes? Until now, all known enzymes have been produced in and by the living organism. While some have been recovered from the secretions of organisms, such as digestive juices and milk, mostly they are obtained from the interior of cells and there is good evidence that they control most intracellular reactions.

How do they get into the cell? If, as seems probable, genes are enzymes, then we may say that there has been a continuity of these enzymes from remote time. May we conclude that the genes are the sole source of cell-enzymes? It is indeed nearly certain that in fertilization of the egg the minute sperm brings only genes into the egg—*i.e.*, nothing but enzymes. Since the contribution of sperm and egg to the course of development of the child is the same, we may conclude that the genes of the egg and only the genes are enzymes.

But the egg, unlike the sperm, contains much material besides the genes. If this material is not enzymes it must be that upon which the enzymes act—the so-called substrate (*e.g.*, in bread-making the flour is the substrate upon which the yeast enzyme acts). For it must be recalled that the genes do not directly constitute the material of the body, but accelerate certain processes of molecular change in the rest of the cell body by which energy is released and the cell body is increased and enabled to produce its specific formed substances, such as are seen in connective tissues, cartilage, bone and certain body fluids.

The cytoplasm affords the building material for growth and differentiation; the genes supervise this growth and differentiation by accelerating the cytoplasmic reactions.

There has been among biologists of this country a sort of division into two groups. One group maintains that the genes are really the builders of the new organism, nourished in some way by the foodstuffs of the cytoplasm. The other group maintains that the egg cytoplasm is immensely important. It holds that the parts of the future embryo are foreshadowed in the distribution of materials in the cytoplasm of the egg.

This controversy seems unnecessary. The genes can do nothing without the cytoplasmic contents to activate. The cytoplasmic chemical processes would be relatively inert without activation by the enzymes. The division of opinion here is as futile as that concerning the relative importance of heredity and environment. Of course, the organism is absolutely dependent on the environ-

ment for its survival; also what the environment does depends upon the nature of the stuff upon which it acts.

It appears that the full complement of the enzymes is brought into the egg at the moment of fertilization. The enzymes are distributed to all the cells of the developing body by the doubling of the chromosomes and their genes at every cell division.

Very early, as we have seen, the cells of the developing embryo begin to undergo *differentiation*. How can the same full equipment of genes in each cell function so differently? To this question Weismann gave his answer: The different cells do not contain the same active genes. There must be a regularly proceeding segregation of the genes in ever smaller groups until finally there remains in each cell only one kind of gene, namely, that which controls or determines the character of that cell. It is highly improbable, Weismann says, that all genes are carried into all stages of ontogenesis.

On the other hand, a careful comparison of the cells of different tissues of the adult body leads to the conclusion that, in general, these cells have the same chromosomes as the fertilized egg, from which they were all derived. However, similarity of chromosomes does not imply identity of their constituent genes; for genes may change without altering the form of the chromosomes.

It is urged that the wide-spread capacity of regeneration of lost parts in various vertebrate species (of which, more anon) proves that somatic cells must contain a full equipment of genes. Indeed, a piece of the leaf of certain plants is able to function like an egg. But this is not adequate proof that all somatic cells contain the same genes, for in all parts of the body there are two kinds of cells, which have long been recognized: First, the relatively unspecialized cells, which probably have a more or less complete set of genes, and which are inactive until called forth by injury; secondly, the active cells which are specialized (or differentiated). It is probable that such specialized cells can not regenerate the whole organism or any considerable part of it.

FIG. 13. HUMAN EMBRYO
AT HALF TERM, SHOWING SLIGHT DEVELOPMENT OF PELVIS AND LEGS (KOLLMANN, 1907).

If then somatic cells in general possess the same chromosomal complex, what is probably the nature of the change in the chromosomes that is responsible for differentiation?

This problem appears less difficult if we consider again how the enzymes work. The work that the enzymes do depends upon the nature of the substrate. Now, under the influence of the enzymes of the genes that substrate is constantly changing. Hence the same genes can not do the same work in dif-

FIG. 14. PHOTOGRAPH OF A BABY AT ABOUT ONE MONTH AFTER BIRTH, SHOWING THE SLIGHT DEVELOPMENT OF THE GLUTEAL MASSES, OR BUTTOCKS.

ferent parts of the body or even in the same part of the body at different times.

We must recall that the action of any particular enzyme is highly specific. Thus, *zymase* (an enzyme from yeast) ferments d-glucose, and is quite inactive with l-glucose. The two glucoses have the same structure except for a different position in the molecule of certain atom-groups. Consequently, for long periods during development, a particular enzyme may have no work to do because the nature of the substrate is such that that particular enzyme has before it no chemical reaction which it is able to accelerate.

To make this clearer, we may consider a series of changes in the cell induced by enzymes splitting up. We may assume that at a certain stage enzyme Ea will cause the hydrolysis of the substrate molecule Sa; and this molecule splits up, into Sb and Sc. Enzyme Ea can not split (hydrolyze) molecules Sb and Sc, but some other enzymes Eb and Ec are able to do so and thus produce new cell products. So in succeeding cell generations.

If, following cell division, the cytoplasms of two daughter cells are unlike (as often occurs) then, though the genes be the same in both daughter cells, the reactions occurring in the cells under the influence of these enzymes will be quite different—and cell differentiation will show itself. Such a differentiation once started will tend to become exaggerated in later cell generations and, in time, the various parts of the developing organism will become very different. Thus, each moment of development sets the stage for the next phase, and time and place of action of the genes are automatically determined.[1]

Adopting the point of view thus outlined I think you will agree with me that the enzymes are extraordinarily interesting and important molecular groups. The enzymes are universally distributed among animals and plants. Even such lowly organized beings as bacteria and yeast show already a rich variety of highly effective enzymes. No enzyme has ever been artificially synthesized. When such synthesis is accomplished a step, if only a short one, will have been taken toward the manufacture, in the laboratory, of living matter from non-living.

But there are other factors to be rec-

[1] A sentence in Wright (1934, p. 32) indicates that he has seen this possibility.

ognized in ontogeny than *kinds* of enzymes. There are the factors of degree and velocity of action. Many traits that differentiate races are of a quantitative order. For example, the newborn Negro child has a cream-colored skin. It is only under the influence of daylight (even very diffuse) that it becomes dark. Many a South European child who is white at birth becomes very dark-skinned when subjected to the ultra-violet rays of the sun. The Negro child simply reacts more quickly and fully to sunlight than the European. We have reason to think that it has more of the tyrosin in its cells, to be turned into black pigment.

European children at birth have blue eyes. In South Europeans, under the influence of daylight, pigment is formed in the iris and the eye becomes brown. The age at which full color is attained varies in different families; in some cases the eye remains light brown, hazel or even blue. The different grades of eye color are merely quantitatively diverse.

Sex would seem to be a sharply marked qualitative character. But the work of the Berlin geneticist, Goldschmidt, indicates that in the gipsy-moth there is a male-determining gene and also a female-determining gene, and that these genes differ in strength in different races. The union of a weak female gene with a strong male gene will produce intersexes among the female progeny. The union of a strong female with a weak male gene will produce normal males in the first generation, but some male intersexes in later generations. The sex actually achieved in the developing organism depends upon the relative strength of the male and female determiners. Thus, there are times when, as it were, one active enzyme struggles against another to secure a place for its products in the development of the body.

We have seen that the same set of genes in each cell may well react very differently because the substrates upon which they act are unlike in different cells. On the other hand, there is some evidence that chromosomal and even gene changes may indeed occur in the cells of the body in the course of the development of the body.

Certain spots, or areas, on the eye or on other parts of the surface of the fly Drosophila are due to irregularities in the *chromosomal complex* that have been induced by x-rays acting on body cells during development. Owing to the occurrence of these mutations first in later stages of development only a small area of the body is affected. Similar results have been found without using x-rays.

In corn grains, in the petals of the larkspur and in variegated plants in general, a definite pattern may arise naturally. It has been demonstrated that this pattern is due to mutations occurring in the genes of somatic cells at a definite time and place.

FIG. 15. PHOTOGRAPH OF CHIMPANZEE SHOWING SLIGHT DEVELOPMENT OF THE BUTTOCKS (A. H. SCHULTZ).

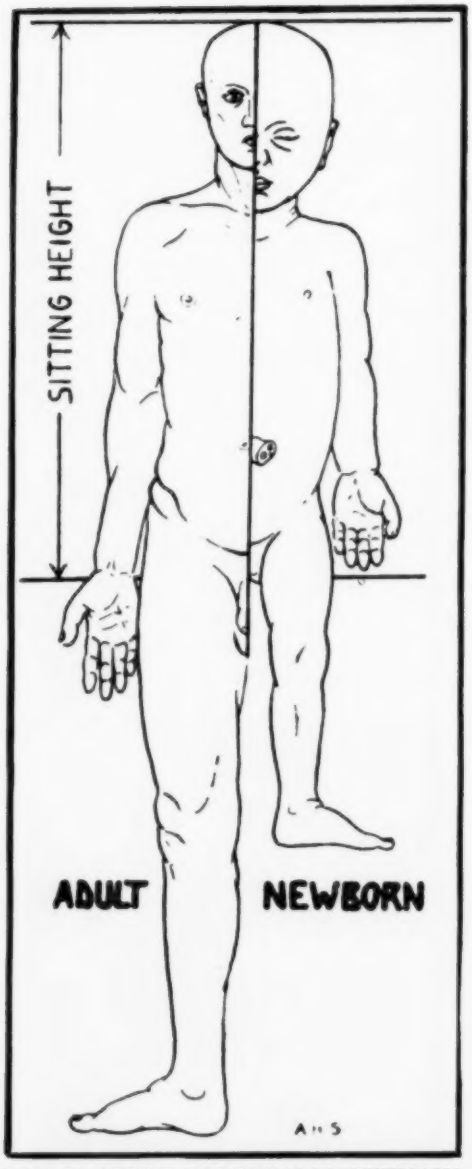

FIG. 16. ADULT AND NEW-BORN HUMANS
DIAGRAMMATIC COMPARISON BETWEEN THE EXACT BODY PROPORTIONS OF EACH, BOTH REDUCED TO THE SAME SITTING HEIGHT. IT IS TO BE NOTED THAT WHILE THE LEG HAS DOUBLED IN LENGTH THE ARM HAS INCREASED ONLY ABOUT ONE-THIRD. THE ARM OF THE NEW-BORN IS PRECOCIOUSLY LONG. (A. H. SCHULTZ).

Thus we see that not only does the substrate of the cytoplasm change under the action of the genes, but the genes may change, perhaps in reaction to the substrate, perhaps under the influence of radiations.

Other classes of differentiating agents that can not be directly due to gene action are harder to understand. For example, in the formation of the eye an optic cup rises up from the primitive brain and touches the embryonic skin. Where it touches the embryonic skin this skin turns down as a pocket, which eventually produced the lens. This reaction will take place even when embryonic skin that was destined to produce the lens is replaced by skin from the belly engrafted on the side of the head in place of the normal skin. The optic cup induces the lens to form even from this foreign skin. Many reactions of this type have been found in the developing embryo.

Even more striking evidence of an organizing action of cell on cell has been found by H. V. Wilson in sponges, in which the cells are rather loosely associated. The cells of a living sponge may be forced through bolting cloth into normal sea water in a receptacle. Soon after the loose cells have settled to the bottom they move toward each other and after some hours they are grouped into a normal sponge structure much as existed before the rough handling. These facts, combined with those of the displaced parts of the skin of the frog embryo which participate in normal development in a foreign location, suggest the presence of certain organizing properties in the developing embryo for which we have as yet no simple explanation.

The foregoing phenomena recall the facts of regeneration. It has long been known that many animals will regenerate lost appendages. When a flatworm

or earthworm is cut in two each piece will regenerate, roughly, what has been lost, so as to reconstruct a functional organism. A great tree may be badly mutilated in a storm, but 10 years later the symmetry of form that belongs to its particular species will be nearly restored. Given the chance and *within limits*, an organic form that has been mutilated will be restored.

responsive to the stimulus of other cells or organs.

Thus, there appear very early in the developing embryo a number of loose migratory cells, resembling the white blood cells. These traverse the cavities of the body, come together to form strands which make eventually the blood vessels. They crowd together below the spinal axis and here develop into a large

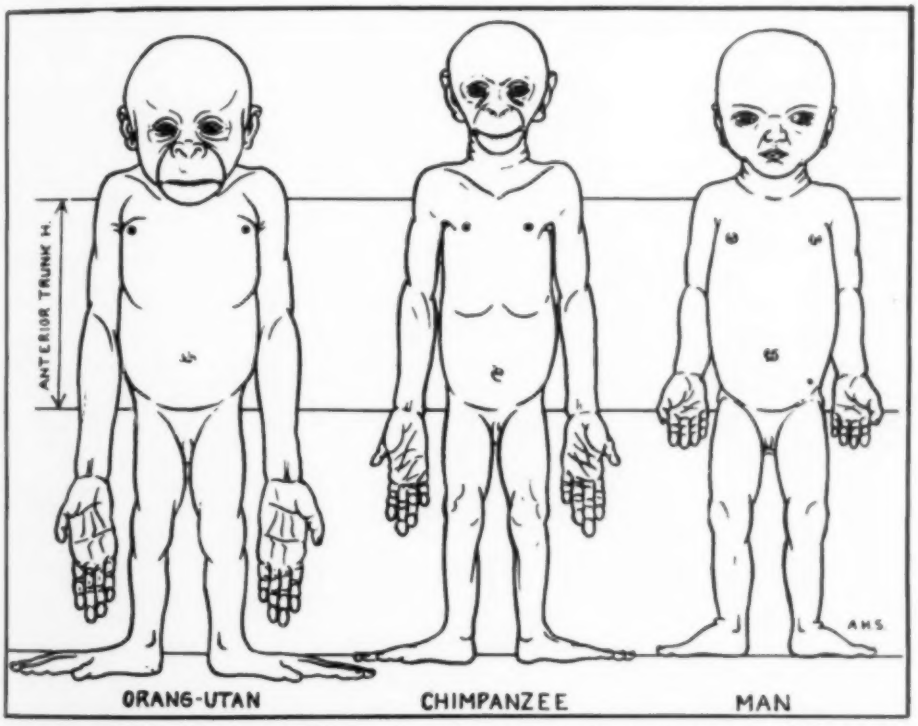

FIG. 17. DIAGRAMMATIC REPRESENTATION OF THE EXACT BODY PROPORTIONS OF NEW-BORN ORANG, CHIMPANZEE AND MAN, ALL REDUCED TO THE SAME ANTERIOR TRUNK HEIGHT. NOTE THE DIFFERENT LENGTHS OF THE LIMBS (A. H. SCHULTZ).

As stated, we know little about the forces that hold the developing organism to its specific form; and restore that form when mutilated. We do know that there is polarity in many elongated organisms and that commonly the head end grows faster than the tail end. Obviously there are other such forces.

At all stages of development the cells of the organism show themselves highly

tube out of which the heart is eventually formed. These primitive vascular threads find their way into the limb buds to supply the growing limb with blood and if (as is perfectly possible) a limb bud is removed from one part of the skin and grafted upon another, some blood threads will find their way to the bud in the new position and penetrate into it.

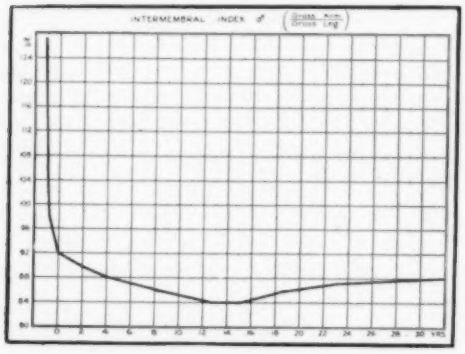

FIG. 18. CURVE SHOWING THE INTERMEMBRAL INDEX IN THE MALE

FOR DIFFERENT AGES FROM BEFORE BIRTH TO 32 YEARS. THAT IS, THE TOTAL ARM LENGTH ÷ TOTAL LEG LENGTH. THE LENGTH OF THE ARM (THAT OF THE LEG BEING 100) IS REPRESENTED BY THE ORDINATES NOTED BY THE SCALE ON THE LEFT.

Again, from the spinal nerve cord there grow out nerves which pass between membranes of the body and make their way to all the developing organs. These pass to the limb buds to innervate the muscles which are to arise there. If an appendage be removed from its normal position and placed somewhere else, a nerve, though not necessarily the one which would have innervated it in its original place, will find its way to the bud in the new place and function there.

What can we say concerning these organ-reactions from the standpoint of genetics? It seems probable that the genes produce substances which exert something of an attraction upon the adjacent organs so as to cause the moving down of the cup of the eye lens, the aggregation of cells to form the blood vessels, movement of the vascular threads toward the muscle masses, the movement of the nerves toward the appendages. We do not know anything definite about the substances which serve as such

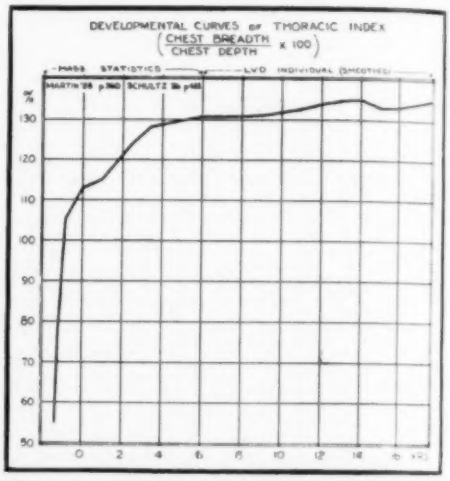

FIG. 19. CURVE OF DEVELOPMENT OF THE THORACIC INDEX

OR THE BREADTH OF THE CHEST; THAT OF THE DEPTH BEING TAKEN AS 100. THE CURVE SHOWS THE VARYING INDEX FROM BEFORE BIRTH TO 18 YEARS OF AGE. BASED ON MARTIN AND SCHULTZ AND NEW DATA.

FIG. 20. CROSS SECTION OF THE CHEST OF AN ADULT QUADRUPED, A HUMAN FETUS AND ADULT MAN

SHOWING THE PROPORTIONS BETWEEN TRANSVERSE AND SAGITTAL DIAMETERS. (A. H. SCHULTZ).

attraction. We infer that in later life the movement of the white blood cells (phagocytes) toward bacteria are determined by certain substances given off by the bacteria into the medium. It is apparently thus that the white blood cells come in contact with bacteria and devour them. This control of movement of one part by other parts is sometimes called *chemotaxis* (or movement toward or from a chemical agent).

Indeed, we take too narrow a view if we fail to realize that cells are capable of acting upon others and being acted upon; of responding to stimuli.

Hitherto we have considered effects that can be referred to simultaneously acting causes. The action of the gene may, however, be far removed from the visible trait for which it is really initially responsible. This principle may be illustrated by the case of the Kinky-tailed mouse (Fig. 12). This abnormality appears in various degrees. Are we to think of a gene for each?

The study of the earliest stages of this defect shows that the Kinky-tail is the end result of a long series of stages, beginning with a gene defect in the embryo showing at the time the embryonic axis was being laid down. Thus the earliest alternations of development were relatively simple; though severe, not fatal. Subsequent development was accompanied by an attempt of the developing organism to smooth out, or adjust itself to, the defect; so that the final form appears quite trivial, though strikingly hereditary. But it has had a long and varied developmental history.

Again, there is reason for believing that genes, instead of acting directly, may influence development indirectly by means of the activity of the endocrine glands which they have built up. These glands, such as thyroid, pituitary gland at base of skull, and gonads (or sex glands) may then take up the work of finishing off the organism. If the thyroid functions inadequately a dwarf cretin results; if the anterior pituitary and surrounding tissue are deficient a fat child with imperfectly formed genitalia develops, or if the pituitary is overactive the child develops into a giant. The entire series of sex-differentiating characters, including female beauty and male strength and vigor, is derived through the gonads. The endocrine glands are intermediate links of the chain that reaches from egg to adult man.

By such a chain of causes we can understand also how athletic prowess may be inherited; not only a general prowess, but excellence in a specific kind of athletics. What the gene does is not to produce a great runner or jumper, but it influences the length of the femur, or of the lower leg. Apparently, a long lower leg and relatively short femur would favor jumping (even as we see in the kangaroo), while a long femur and short lower leg fits a person for rapid running (even as we see in the gazelle). The developing boy who finds himself genetically provided with long thighs finds that he can run successfully and this gives him so much pleasure that he is apt to enter into competitive sports which involve such running. Because length of thigh is inherited we have families of great runners.

In summarizing the facts of differentiation presented we are amazed at the complexity and variety of processes involved. The genes act directly upon the cell substrate to build up the stuff of which the body is composed. Because the genes or the substrate are different in each child (apart from certain kinds of twins) the adult body is different from that of other children. These genes may differ in speed of interaction in different parts of the body causing differential velocity of growth and differentiation. The genes in body cells may locally mutate in regular fashion so as to produce a new pattern.

Besides the direct action of gene on

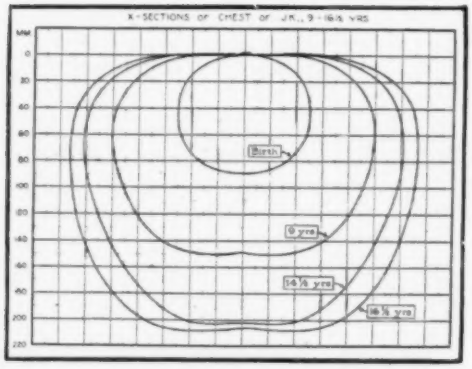

FIG. 21. CROSS SECTION OF THE CHEST OF J. K.
AT 9, 14½ AND 16 YEARS, AND FOR COMPARISON THAT OF THE NEW-BORN, SHOWING CHANGES IN RELATIVE LENGTH OF THE TRANSVERSE AND SAGITTAL DIAMETERS.

substrate we have the phenomenon of organization of the part or the whole body, by which isolated pieces of the embryo go through their destined course under new conditions, though they may force adjacent parts to cooperate with them in a (for them) strange and new course of development. This organizing force leads many mutilated parts to be regenerated, may even cause the separated cells to come together to restore a disrupted being. Throughout the entire developing organism one part is acting upon and securing response from other parts. One could almost compare the organism to an ant colony in respect to the cooperation between part and part. It seems possible that this organizing property inheres largely in the body as a whole, rather than its cells and genes.

Finally, there are many links in the chain between the genes in the egg and the fully developed adult characteristic. The embryo builds up organs for the adult that help complete its development and, as endocrine glands, ensure its constant adjustment to a changing environment.

III

In tracing the development of the child from the egg we have seen that it passes through a series of stages which have apparently little meaning for the grown human and which remind us of stages that are found in the development of the lower vertebrates. For example, I have referred already to the stage of elongated neck with its gill-bars, so similar to that of the stage of the development of the fish. It is easy to see in detail that the human embryo passes through many stages that are characteristic of the young of other species and that may even persist into the adult stage of those other species, though disappearing in the adult stage in man.

For example, a child before birth (Fig. 13) and for some weeks thereafter (Fig. 14) has the great gluteal masses (or buttocks) undeveloped, and on this account can not walk. This stage is that of the chimpanzee (Fig. 15), which can not walk well either.

Again, the relatively long arms and short legs of the human fetus (Fig. 16) are very similar to the early formed long arms of the chimpanzee fetus, which persist in the adult chimpanzee, though the arms become relatively short in the adult human (Fig. 17).

Indeed, the child at birth is far from having completed its development. It goes on showing changes which had been anticipated in intrauterine life until eventually the proportions of the adult are acquired and growth gradually slows down at, or before, the end of the second decade. I will give a few examples.

The change in proportions of arm and leg is brought out in the graph of Fig. 18, in which time (age) in years is marked along the base and the size of the index: arm length/leg length is indicated by the length of the verticals—leg length being taken as 100.

One sees that in the embryo at the third month the arm is one quarter longer than the leg; at birth the two are nearly equal in length, that thereafter the legs grow relatively faster and faster, until, in the girl at about twelve

and the boy at about fourteen years, the arms are about four fifths as long as the leg. After that the legs nearly stop growing and the arms keep on for a little while longer.

Another example—The chest of the child at birth (Fig. 19) is very nearly a cylinder with approximately equal axes. If one thinks of the dorso-ventral axis as 100, then at birth the transverse axis is about 110 (Fig. 20) but increases rapidly to about 125. After that it falls behind, while the dorso-ventral axis increases, but eventually this axis stops growing and the transverse axis continues its increasing breadth. Thus, there is in the development of the child a rhythm in growth, producing changes in proportions.

How do we account for these changes? First, it appears that the cylindrical chest of the human fetus is a generalized form that is found in the fetuses of lower Primates and, indeed, in the adult monkeys. While in some low mammals, like the dog, the dorso-ventral axis (Fig. 20) becomes in the adult the greater, in adult man it is the transverse axis that comes to dominate. The changes that the index of the axes of the thorax undergoes during prenatal life and subsequently to 17 years is shown in Fig. 21 (one and the same boy). The chest at first has nearly equal axes, gains great breadth by 9 years, gets deeper at adolescence and broadens slightly in later life.

This resemblance of certain stages of development of the child to later stages, and even adult conditions, in the lower vertebrates was the thing which led Von Baer to the generalization that in recapitulations of ontogeny the child passes through steps that lie along the lines on which man is supposed to have evolved.

It is obvious that the child does not generally develop the forms which are found in the *adults* of the lower vertebrates. It is, however, true that the lower vertebrates and the child pass through similar stages in early development, and that at a certain point the line of development of the human child diverges from that of the line taken by some of the lower forms, so that the adult conditions of the two become very different, as, for example, in the transitory embryonic gill-bars.

We may say, in general, that the early developmental stages of the vertebrates show many organs in common, though these organs may be only temporary in their appearance in the higher forms. They represent, as it were, the scaffolding necessary to the erection of the building, but something that is of no further use, once the building is completed. Accordingly, when the building is finished the scaffolding is removed.

The similarity in the development of the human fetus and the young of other Primates and other mammals and vertebrates is, however, clearly one of the strongest arguments for the conclusion that these are all related, and it is only in the later stages of development that they have become different from each other. The development of a child can take place only along a narrow path, and for some distance that path is a

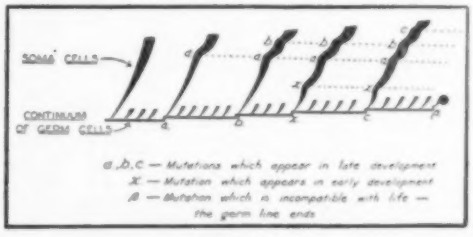
SOMA'S CELLS
CONTINUUM OF GERM CELLS
a
b
c
X
B
a, b, c — Mutations which appear in late development
X — Mutation which appears in early development
B — Mutation which is incompatible with life — the germ line ends

FIG. 22

DIAGRAM SHOWING AT THE BASE THE CONTINUUM OF GERM CELLS THAT PASSES THROUGH THE AGES; ALSO THE SOMAS THAT ARISE FROM THEM (ONLY FIVE REPRESENTED IN EXTENDED FORM). ILLUSTRATES THE INHERITANCE AND PILING UP OF INHERITANCES OF MUTATIONS IN THE INDIVIDUAL SOMA. FOR SIMPLIFICATION, THE ILLUSTRATION IS DRAWN FROM A PARTHENOGENETIC SPECIES, LIKE DAPHNIA; SO IT IS NOT COMPLICATED BY SEXUAL REPRODUCTION.

well-worn one that has been trod by its ancestors and which is still being trod by many related mammals.

What is now the mechanism by means of which these new characters and new proportions enter into the individual development? These characters depend largely upon changes in the genes of the germinal substance, which changes are called "mutations." The mutations are alterations in the substance of the genes or they may be changes in the arrangements of these genes in the chromosomal complex.

Whatever they are, these mutations which ordinarily first appear in the germ plasm show themselves by alterations in the form of the individual that arises from that germ plasm and they are reproduced in the subsequent generation, because the subsequent generation arises from that modified germinal plasm. The relation of the germ plasm and the change in the adult may be visualized in a diagram (Fig. 22) in which I show a series of mutations in the germ protoplasm A, B and C. These modifications persist in that germ plasm and the modifications which they induce recur in successive generations that arise from the modified germ plasm. Most of the mutations that survive affect last-formed organs. Mutations of early stages would probably cause death.

Summary

In conclusion, the development of the human child, like that of the young of other mammals, is a series of changes in size, proportions and complexity of parts that is clearly directed by internal factors—genes.

These genes do their work by relatively simple processes that direct cell division, growth of the body as a whole, and of its parts. They determine the fate of the tissues either directly or through the hormone-producing endocrine glands that they create. The successive situations or stages reached at any moment afford the situation to which the appropriate gene or genes respond. Between the genes in the cell nucleus and the cell environment is constant action and interaction as stage after stage is built up.

Besides the genes there is an organizing agency which controls form of the body as a whole. Now, the course of development is not arbitrary because it is not new. It proceeds along a necessary path—a path worn by its early vertebrate and early mammalian ancestors. In so doing it recapitulates, in part, the ontogenesis of those early ancestors and reveals to us in an only partly obscured light what those ancestral ontogenies looked like.

The development of the child is not finished at birth and, indeed, for twenty years after birth it goes on changing, guided ever by the traditions of former remote ontogenies. However, step by step the growing child incorporates the more recent mutations at the appropriate time and place.

Genetics is the study of the way a changing body reacts in the presence of a complex system of responsive genes to build up in well-established fashion an organization capable of surviving in its environment and thus of nursing and transmitting further the potentially immortal germ plasm that it carries.

CLIMATE AND HEALTH

By Dr. EARL B. McKINLEY

PROFESSOR OF BACTERIOLOGY AND DEAN OF THE SCHOOL OF MEDICINE, THE GEORGE WASHINGTON UNIVERSITY

MAN is a creature of his environment. So often has this been said that we have come to believe in this all-inclusive statement as one which requires no further definition. As a matter of fact there are many different types of environment, such as physical, social and intellectual (to mention only a few), as there are different types of human beings in these respects, though the development of our civilization has shown that increasing importance and significance should be attached to the effects of combinations of environments, particularly when we attempt to evaluate any one as to its influence upon the complex human organism. With regard to climate and its effect upon physical man and his state of health, which is the subject we wish to discuss here, we have learned with what difficulty it is possible to establish controls in the purely scientific aspects of the subject and we realize that, as yet, much of the advance in this field must have its genesis in the realm of philosophy before the laboratory of environment can test the principles and hypotheses which are evolved.

The subject of climate and health is almost as old as man himself. Since the early records of time reference has been made to conditions of climate and disease. In ancient days it was common to associate the plagues of disease with climatic changes thought to have been wrought by the Deity as a form of punishment for a wicked world. Philosophers early postulated the miasmatic theory of the origin of many diseases, and it is only comparatively recent that scientific demonstration of the germ theory effectually destroyed this doctrine of a less enlightened period. We have then in the subject of climate and health one which reaches back into the dark ages, and even to-day, as we shall see, a scientific approach to this ancient problem is only in its infancy.

A more modern point of view regarding climate and health was initiated early in the seventeenth century with the formation of the East India Company under a charter granted by Queen Elizabeth. The early adventurers in the field of medicine who went to India soon began to think and write concerning the climate and associated health problems. It was inevitable perhaps that climatic contrasts which these men from more temperate climates experienced should have focused their attention upon this problem. And yet only the most general observations came from these early pioneers and we find no scientifically controlled studies in the records. However, their contribution remains a definite one, since they served to emphasize the importance of the subject.

In recent decades the problem of climate and man has been the subject of several notable reviews. Among these may be mentioned such studies as those of the Carnegie Institution of Washington in 1914 on "The Climatic Factor as Illustrated in Arid America"; "Civilization and Climate" by Huntington, first published in 1915; "The Tropical Sunlight" by Freer, 1910; "The Physiological Effects of Tropical Climate" by Sundstroem, 1922; "Climate and Acclimatization" by Castellani, 1929; "Medizinische Klimatologie" by Brochardt, 1930, and many shorter treatises dealing with various phases of the subject, some

of which will be referred to later. At the present time Mills has a monograph in press dealing with climate and health, several chapters of which are available to the writer in manuscript. Still another evidence of the increasing interest in this subject is the recent formation of the International Association for Geographic Pathology, which indicates a recognition of the principle that there exist geographic differences even in the effects of disease.

A few years ago Huxley stated so aptly that "Man's thought and social life are built on his economic life; but this, in its turn, rests on biological foundations. Climate and geology between them decide where the raw materials of human industry are to be found, where manufactures can be established; and climate decides where the main springs of human energy shall be released. Changes of climate cause migrations, and migrations bring about not only wars, but the fertilizing intermingling of ideas necessary for rapid advance in civilization." This author further stated that "Disease and hygiene play as important a part; half of the population of the world is permanently below par on account of animal parasites such as the hookworm and the microscopic malaria germ; and disease may bring about the rise or fall of empires. Nor has selection ever ceased its rigorous activity. To pass from one mode of life to another is not a simple affair for a people; a settled agricultural life demands a very different temperament from hunting, and the hereditary make-up of the race must be altered if a people is to pass successfully from one to the other. . . . The only zones where vegetation is abundant and man can easily flourish are the temperate and the tropical. But the temperate has another advantage. It contains the belt of cyclonic storms—in other words, of rapid and frequent changes of weather. And this type of climate, as Ellsworth Huntington has shown, is the one most stimulating to human energy and achievement." In these few observations of Huxley we have a concept of the problem and some indication as to its deep import. With this brief historical background and introduction to the subject of climate and health, let us proceed to a definition of the terrain and a discussion of our specific problem.

Climate is usually defined as the temperature and meteorological conditions of a country, or as the effects of the sun, atmosphere and earth upon living objects at a given place on the earth's surface. Thus, radiant energy is one of the elements of climate, as are also humidity, rain, snow, wind, density, electrification and temperature, all of which determine, with other factors, what the atmosphere shall be. These various elements, according to meteorologists, are dependent upon fixed and natural factors. It is because of these many elements of climate, which are dependent upon fixed and natural factors, that so many variables exist in the study of the problem of the effect of climate upon living objects. In the field of physiology of climate Sundstroem apparently recognized these limitations, for he emphasizes the study of problems in this field by "groups" in the tropical belt "as a whole" when, as he states, it will be possible to follow up any promising phase to a point beyond mere "suggestions" with due consideration of the correlations with other body functions, and when, consequently, the whole science of physiology will be placed in the tropical frame.

Climates are usually classified as (1) astronomical, (2) geographical, (3) topographical and (4) physiological. Castellani refers to the classification preferred by Supan, namely, the solar or astronomical basis of division. In this classification we have (a) tropical or

warm climates, extending from the Equator to the mean annual isotherm of 20 degrees C. or 68 degrees F., (b) temperate climates, extending from lands possessing a mean annual isotherm of 20 degrees C. or 68 degrees F. to those which have a temperature of 50 degrees F., and (c) cold climates, lying polewards of the isotherm of 50 degrees F. This is perhaps the simplest classification and one which will serve our purpose as a basis for discussion, though we must not lose sight of the modifications of these divisions which geographical and topographical features bring into the picture, such as continental and oceanic considerations or, by contrast, the variations between mountainous areas and the plains in the topographical scheme. The climate of Baguio, for example, is more invigorating in the Philippines than that of Manila or Culion at sea-level, where the effect is of a relaxing type. Scores of examples of this type in both temperate and tropical climates might be mentioned where often, from the physiological point of view, marked differences exist when altitude compensates in part for latitude. Frequently such variations may be encompassed within the limits of a few miles as the crow flies.

We have seen that man builds and adapts his social existence upon his economic life. It is because of this that we have movement from one place to another and now and then large migrations of people take place almost *en masse* from one part of the world to another. Centers of new population have thrived only where the fundamental necessities of fertile soil and water exist. Given a fertile soil and a supply of good fresh water the factor of health is of next importance, although health can not be dissociated from man's fundamental problem of nutrition. It is therefore because of migrations that we must consider health problems first and so the question of climate and health may be regarded as one which is essentially basic to man and civilization. To understand something regarding the relation of climate and health we must study the effects of the former upon the latter. In a gross fashion it may be possible to state offhand that a given climate may or may not promote good health. The making of such a statement, however, is merely lifting the lid from a large pandora box, the contents of which must then be carefully sorted and examined. It is this sorting which has given trouble, for the contents of the box, corresponding to the elements which make up a given climate, vary not only among themselves in type but also vary in degree and we find ourselves surrounded by a maze of things which do not explain everything as we had hoped when we lifted the lid. If we wish, for example, to test the effect of a drug on a living organism we first select a normal individual for the experiment. Next comes the question of the amount of the drug to be employed. A small dose may produce certain effects, while larger doses may produce more pronounced effects and additional changes as well. Although many of the changes can be measured and accurately charted, we are assuming that in the first instance we have selected a *normal* test organism. Here the first error may enter our experiment. Admitting that our test organism may be as *normal* as any of its species, it does not necessarily follow that the action of the drug on this organism will be the same for the so-called normal member of another species, and further we know that organisms of the same species may vary one from the other in type and degree of response to the same stimulus. And so in the study of the effects of climate on normal man we are handicapped at the outset in two very important ways, namely, the variables of the climatic elements themselves and the multitude

of "combination effects" which they may produce due to individual variation in degree and man himself, the test organism in this particular problem, who notoriously possesses individual characteristics which hereditary factors have, in the beginning at least, determined for him. Fortunately, however, within these limits, certain general effects may be expected to be brought about by extraneous agents in various members of a given species and, to compensate for the differences which nature has provided, we employ a sufficient number of the test organisms in order to compute *an average effect* of our test agent. Care must always be taken, however, to take into account other causal effects which may unintentionally enter the experiment.

Let us at this point briefly mention some of the effects which are said to occur in man who has migrated from a temperate climate, which is characterized by unsettled weather with variable changes in temperature, rainfall, moisture, storms, cold and hot waves, floods and droughts, to a tropical climate, which is characterized by being mild, equable, moist, warm, with frequent rainfall and heavy over water and over windward land exposures, with few general storms and with dry and rainy seasons. Leaving aside for the moment certain racial peculiarities (such as the Negro of Africa, who is well adapted to his warm climate, or the Latin and Jewish races, who seem to be less affected by climatic changes) and considering the Anglo-Saxon as our test organism, let us see what general effects we may expect from reported studies, on the average, to take place. The literature would indicate that under such conditions of change in climate there is a tendency for respiration to be slower and for pulmonary capacity to be increased; body temperature is said to rise slightly at first but to return to normal in the individual who acclimatizes readily; some investigators have reported an increase in the pulse rate, while others claim there is a diminution in the rate; differences in blood pressure have been noted, some investigators asserting there is no permanent change, while others claim the systolic pressure may be lowered as much as ten to twelve points and the diastolic pressure in similar proportion; haemoglobin is said by some authors to be decreased in tropical climates, while the red cell counts may remain normal, but there is no agreement regarding this matter; the blood sugar, it has been claimed, is higher in tropical climates, but some investigators have found normal values or even slightly lower readings than normal; the cholesterin of the blood is generally stated to be somewhat lower, the non-protein nitrogen is said to rise during the warmer periods, while the phosphorus content of the blood is said to diminish; growth in stature but not in weight has been suggested; the age of sexual maturity is said to be lowered; hot climates are said to predispose to sterility of women, to menstrual abnormalities, to abortions, post-puerperal hemorrhage and an earlier menopause. There is said to occur a lowered power of digestion and a tendency towards constipation; several reports indicate that there is a lowered basal metabolic rate, but other reports deny this; a depressing effect on the nervous system has been described; urinary secretion is said to be diminished and there is thought to be an increased concentration. In addition to these general observations it may also be mentioned that certain investigators have claimed that the endocrine glands are at first stimulated in tropical climates and later depressed. The adrenal glands particularly are said to be adversely affected. Sexual power is at first stimulated, according to some observers, and later

definitely depressed after prolonged residence in warm climates. There is said to be an increased elasticity of tissues, resulting in a general sluggishness and relaxation.

The warm climates are also said to predispose to various skin diseases, such as fungus infections and to bacterial and parasitical diseases in general, due to the debilitating influences already mentioned, which may tend to lower general body resistance. These are only a few of the vicissitudes about which the average Anglo-Saxon might be concerned, should he contemplate transplanting himself to a tropical climate from a colder environment. But how much of this is factual and really established upon a scientific basis? We venture to state that very few of these observations are as yet firmly established. For several years the writer has been interested in this question, and a thorough study of the literature together with more than casual observation of some of these problems has convinced him that, as yet, few fundamental basic observations or principles have been established in this field of study. However, these various observations are deeply significant. The reports of the many investigators who have worked with these problems contain, without doubt, factual observations upon the particular groups studied by them in the particular climatic environments under which their observations were made. There would seem therefore to undoubtedly exist a distinct realm of study and knowledge in this field of climate and health and one which should be the subject of an aggressive, though conservative, scientific attack.

While contrasts in climatic change, such as movement from temperate climates to tropical climates, must bring about physiological alterations in the human organism, it is also probably true that movements of people from the warm belts to the colder climates also produce definite physiological changes. Whether either of these alterations *per se* so affect the individual as to change his resistance and susceptibility to infectious diseases is not established. There has been much loose thinking about this question. It must be remembered that bacterial and other parasitic agents of disease are disseminated largely by human and other carriers or by actively infected individuals themselves. The movements and interchange of people back and forth across the Tropics of Cancer and of Capricorn must determine largely this question of the dissemination of such diseases and not the changes in climatic environment. It has frequently been stated that respiratory diseases are more prevalent in temperate climates than in tropical areas and the pneumonias are frequently cited as examples. This is only a half truth and a misleading one. Only a few years ago the writer was informed that pneumonia is uncommon in Puerto Rico, but subsequent study of this problem revealed that the pneumonias are not an unusual condition in this island. With the constant interchange of people between Puerto Rico and the United States, particularly with New York City, this is not surprising and, indeed, was to be expected. Furthermore, during the great pandemic of influenza some fifteen years ago the tropics were not spared, particularly those tropical areas where the reservoir of infection potential was raised high enough to initiate an epidemic. It must be kept in mind that migrations of individuals from temperate climates to tropical climates are still at comparatively low levels. Scarlet fever is also considered quite rare in tropical countries, but there is nothing certain, as yet, that there are any climatic influences which prevents the spread of this disease in warm climates and if the

carrier level for the causative agent were to be raised sufficiently high in tropical countries it is possible that this disease would also be prevalent, as it is in colder climates. By the same token we have recently learned that amoebic dysentery, while being a disease most prevalent in tropical countries, is no respecter of climates. When conditions of human congestion and faulty sanitation occurred in Chicago during recent months and the infection was introduced, it was spread to hundreds of people, many of whom are now scattered in different parts of the United States. These things, we believe, are not fundamentally a matter of climate, though climatic factors have no doubt indirectly, at least, influenced the picture.

In Siam we are told that urinary calculi are most prevalent, but that gall stones are uncommon. The question arises whether several factors do not contribute to the high incidence of bladder stones in such countries, such as water intake, concentration of urine, calcium and other salts in the water supply, the squatting posture commonly employed during urination, which tends to leave a residual urine in the bladder or perhaps elements of diet or a vitamin deficiency. The answer to this question is not known as yet, but it will most probably not be found entirely associated with the conditions of climate met with in Siam. Nephritis and diabetes are also less prevalent in tropical countries than in cold climates, though several writers, upon theoretical grounds, have assumed that the former should be quite prevalent in warm climates due to disturbances in water regulation and accompanying retention and concentration of urine. While diabetes occurs in tropical countries, its incidence is much lower than that of temperate climates, though due perhaps to other factors than climate. Rheumatic fever is also less prevalent in tropical climates, as are many other diseases believed now to be of infectious origin, but here again we are dealing with germ diseases and we have seen that other factors operate in their dissemination and climate plays perhaps only a minor rôle.

It is readily seen that many questions have been raised in regard to this question of disease and climate. The tendency has been to lay as much stress as possible upon climatic influences. This is perhaps a hangover from our early concepts of tropical medicine. We quite naturally came to think of tropical diseases as affections which were peculiar to the tropics when, as a matter of fact, only a few of these diseases would be peculiar to tropical environments if given a favorable opportunity to be introduced and spread in temperate zones. To be sure, there are certain diseases spread by insects which will probably always be more prevalent in warm climates, since arthropods tend to thrive best in such climates; but it must not be forgotten that malaria was not unknown in former years in our northern states and yellow fever could exist even to-day fairly far north in the United States, where its mosquito vector is prevalent a few months out of each year.

Climate again is only indirectly involved in the picture. In the survey of tropical diseases, which is now under way in the National Research Council, we have listed over eighty diseases which are usually included among the so-called tropical diseases. It is not the thought of the advisory committee on this study that these diseases are of tropical origin in the sense that they thrive only in tropical climates. Most of these diseases could occur anywhere, and it is because of this possibility that the survey is being made. With a world which is constantly growing closer together through

modern methods of communication and transportation, it is important that we learn as much as possible regarding this large group of diseases which, at present, largely inhabit tropical countries. Unfortunately, but necessarily, this group of diseases must continue to be referred to as tropical diseases, since no better designation is available. But the usual emphasis of climate *per se* as the chief responsible factor in their distribution must be dismissed. Rather should we think of these diseases as a group the incidence of which is highest in tropical countries for various reasons, including a favorable climate, or at least a climate which is not unfavorable, and then let us consider climate in its proper relation to these various health problems and through the scientific method determine where and how it fits into the panorama. In general, much of what can be said of this question of climate and health in relation to warm climates and temperate climates can also apply to arctic areas, though scarcity of population in these areas at present makes this problem a comparatively minor one.

Let us therefore return again, at this point, to our original premise that the human race builds and adapts social existence upon economic life. We will not, however, forget the biologic fundamentals or the rôles climate and geology must play in this social existence and economic life. Civilization has developed to its greatest heights in temperate climates. In these stimulating zones of definite seasons and climatic changes from day to day great industrial and agricultural developments have taken place. The per capita of wealth has, with few variations up and down during relatively brief periods, steadily increased. Hand in hand with this we have seen the organization of community life supported by community funds through taxation and philanthropy. Of chief importance in this development has been the organization of health programs. Along with modern water supplies these communities have developed modern methods of disposing of sewage and other refuse. Streets and alleys have been paved and trunk lines of paved highways have been developed between villages, towns and cities. Modern methods of illumination are found nearly everywhere. With the increase in wealth better and more commodious homes have been erected as have schoolhouses, community halls, churches, auditoriums and theaters. Health inspection and laws protect food supplies. The school physician and nurse have been recognized as community assets. Health departments and hospitals have developed clinics for the poor, and governments, both state and federal, have established institutions for the mentally sick and for specific diseases, such as tuberculosis. This development is still going on and will probably never fully meet the complete needs of our increasing populations. But already, as a result of these enlightened developments, we can evaluate much of what has happened. Many diseases, formerly common, are now considered rare. A community formerly considered malarious is now free of the disease, and typhoid fever, for example, is practically never seen by medical students in some of our northern institutions during their entire four years of training. A hundred years ago these diseases flourished in various parts of the United States and Europe—now they are not so common, except in certain areas. Modern sanitation, mosquito control, specific immunization, preventive medicine and health education of the individual and community have changed the picture.

Contrast this with conditions in the tropical belt. Here bare existence must be extracted by hand almost entirely from the soil. Wages are usually piti-

fully low and capital is scarce. Industries of our modern civilization are practically unknown. Poverty is the rule rather than the exception. Density of population is becoming an increasing problem. Housing is inadequate and unhygienic and in its type of construction contributes itself to diseases of many types and protects only from the elements of weather. For the most part there is no safe water supply, no sewage disposal, no hydroelectric power and consequently only the poorest of illumination. Educational facilities are the exception rather than the rule. Food is scarce and of limited varieties. There is little or no health inspection. Life is still primitive. Disease is rampant, the life span is short and infant mortality is extremely high. Due to climate, we say? Only indirectly. If the same standards of civilization were prevalent in the tropical belt to operate for the benefit of the untold millions of inhabitants as these high standards operate for the benefit of man in temperate climates, the picture would be vastly different. Evidence of the truth of this statement is easily found in those tropical areas where high standards of living have been introduced, but unfortunately modern civilization, as we know it, has never touched most of the tremendous area of the tropical belt. There lie ahead of us, of course, vast areas for industrial and trade development among these millions of people in tropical climates who need nearly everything which man in temperate climates possesses and considers essential in his everyday life.

With these considerations in mind, are we still to regard the native of warm climates as the victim of his climatic environment? Indirectly, yes, because his climate is generally considered less desirable and other people will not turn to it for permanent abode until their economic life demands it. But aside from these considerations has the tropical climate a direct bearing upon health? For both the native and also for the emigrant we believe this must be answered quite definitely in the affirmative. Given all the benefits of modern civilization we feel there would still exist a hazard to the fullness of health in the warmer climates. Aside from general observations, whether established or unproven as yet, which have already been mentioned, there is direct experimental evidence that certain elements of such a climate are capable of producing profound effects upon living organisms. Sundstroem, for example, has shown that the humid heat of warm climates constitutes a growth-retarding factor for mice and rats under experimental conditions. In mice which were grown in a "tropical room" he demonstrated a temporary growth stimulation, though he states succeeding generations may behave differently, and after a couple of generations with extremely stunted growth a generation was again reared which exhibited a more satisfactory growth. This investigator states that strong light alone was shown to possess a growth-stimulating effect, but when combined with humid heat suppressed the growth below the levels exhibited by the series exposed to only humid heat. Further improvement followed when motion of the hot and humid air was produced with electric fans. Sundstroem believes that any measure which raises the cooling power in a humid and hot environment will at least partly neutralize the growth-retarding effect of the tropical climate. Further experimental observations are recorded by this author on the retardation of the growth of hair on animals kept under tropical conditions, which correlates with observations which have been made upon man. Similar observations were made for the growth of the nails. Pigmentation of the skin in tropical climates is also affected, as

judged by observation on man himself and the application of the experimental method to animals.

There is also experimental evidence accumulating that the endocrine glands are affected in their function by tropical climates. Hart, Mills and Stoland and Kinney have all reported a decreased function of the thyroid gland in animals reared in hot environments. Perhaps the observation concerning a drop in basal metabolism in similar environments by Sundstroem may be related to these experimental observations. Dunn has reported an increased toxicity of insulin when temperatures of the rooms were increased in which the animals were kept. Knipping has described changes in the cellular structure of the hypophysis in swine imported to tropical countries. Steinach and Kammerer have reported proliferation of the interstitial cells of the testes of rats which were reared in a warm environment. McKinley and Rivera reared standard white rats under controlled conditions in tropical sunlight and have described profound effects which were produced in the testes and adrenals of these animals. The intensity of the ultra-violet light of the sun during 131 hours of exposure of these animals was recorded by Hernandez and McKinley.

It will be recalled that Schanz in 1919 studied the effects of definite regions of the spectrum on a variety of plants. This author found that plants grow higher the more the short rays of sunshine are excluded. The greatest height was obtained under red light and the minimum under blue light. Chlorophyll development in certain plants was more rapid under red light and retarded apparently with the shorter rays. Equally of interest is the work of Kammerer, who has reported the development of a functional eye in the blind cave salamander when exposed to light and the report of Sheard who, in 1926, described the growth-promoting effects of radiation from a quartz mercury lamp upon frogs' eggs which persisted for twenty-four hours, was then retarded, and was followed on the third day by abnormalities of development. Likewise, Northrup, in 1925, found that the larval period of *Drosophila* was shortened slightly when exposed to Mazda lamps at intensities around 2,500 metercandles, but were increased at higher intensities. When we come to mammals we find that, according to Frank, children up to two years of age show a sharp rise in the growth curve from April to June, a drop during the summer months, a second rise in September to November and there is a dip in the curve again in December and January. Sundstroem, however, reports that growth of children in Australia does not differ from that of children elsewhere. Borissow found that dogs and rabbits grown in light weighed more than those grown in darkness after a few weeks under these conditions, though Degkwitz has found practically the opposite for puppies. Interesting reviews on radiant energy are to be found in the monographs of Laurens and Luckiesh.

To refer again to our own experiments along this line of investigation in 1929 sixty white, male rats, three weeks old, average weight of forty-four grams, were placed upon Sherman's 13 standard diet. Each animal was placed in a separate wire cage. Half of the animals were raised in a darkened room, while the other thirty rats were placed in the sunshine each day for varying periods of time. This experiment was carried on at the School of Tropical Medicine, in San Juan, Puerto Rico, and was begun late in November of that year. The experiment was continued for eleven weeks and was terminated the end of the first week in January, 1930. Each day the food consumed was weighed and

charted, the animals of both groups being permitted to eat only during the night. Once each week the animals were weighed and the food consumption for the week was calculated and the loss or gain in weight for each animal was recorded. The total of hours of sunshine to which the experimental animals were exposed was tabulated each week. As a rule the animals were exposed to the sunshine in the late morning and early afternoon hours when the greatest intensity of radiant energy, barring certain factors, prevails. The individual cages containing each animal were placed upon a chicken wire netting raised about eighteen inches off the ground, and the cages were so constructed that the animal had no opportunity to seek any shadow for protection against the sun's rays. The total number of hours of exposure to tropical sunlight for the experimental group of animals was 131 over the eleven-week period. At this point it had been planned to test a certain group of these animals for resistance against an infectious agent, controlling these animals with a similar group of the animals which had been raised in a darkened room, but these plans did not materialize. Consequently at the end of the experiment the animals were all weighed, were then killed and the weights of the adrenal glands, the two testes and the spleens were determined.

It will be noted that the control animals at the end of the eleven-week period had an average weight of 156.6 grams; that their average weekly gain in weight exceeded that of the sunlight group by a small margin; that their total gain quite definitely exceeded that of the sunlight group; that their intake of food was nearly 25 per cent. greater than the sunlight group; that their adrenal glands, on the average, were lighter by a small margin than the sunlight group, even though their total body weight was definitely greater; that their testes were nearly twice as heavy as the testes of the sunlight-exposed rats and their spleens were considerably heavier, which might be explained, of course, on increased body weight alone. The sunlight-exposed rats, in addition to being smaller, were not as active or alert as the control group. They had a smaller weekly gain in weight, but also they had a smaller weekly intake in food. However, although the animals were smaller, their adrenal glands were somewhat larger than the control group, but their testes were only half as large as the control animals.

These experimental results, under such well-controlled conditions, led us to believe that there might be in these observations something of decided importance. The marked delay in maturation of the testes and the delayed involution of the adrenal glands in the sunlight-exposed rats indicated that perhaps great intensity of radiant energy over a long enough period might bring about significant physiological changes in a test animal.

The following year we decided to repeat the experiment during the same season of the year in the same environment, but this time we measured the solar intensity each day by the oxalic-acid-uranium acetate method, and in addition we decided to study the effects upon other organs, such as the thyroid and thymus, and to include some female animals in the experiments so that the ovaries might be compared in the two groups.

The second experiment was begun early in October, 1930, and the study extended to the third week in January of 1931. In this experiment there were eighteen rats in the control group and there were 19 animals in the sunlight-exposed group. At the end of the 14th week the average weight of the control animals was 139 grams and that of the

experimental group was 134 grams, or approximately the same. The food intake of both groups was approximately the same, indeed within 0.3 of a gram according to our figures, though the actual difference may have been somewhat larger than this. Again, the average weight of the adrenal glands of the sunlight-exposed group was higher than that of the control group, but no such difference, as in the first experiment, was obtained for the testes. In the second experiment the weights of the testes were nearly the same in both groups of animals. In this experiment the experimental animals were exposed to 136 hours of tropical sunshine, which in actual measurement accounted for the decomposition of 1067.32 mgms of oxalic acid in the presence of the catalyst when exposed to the sun in a quartz cell. This corresponds roughly to about 350 erythema skin doses for the skin of human beings. The few female animals in both groups showed the ovaries of the control group to be slightly heavier than the ovaries of the sunlight-exposed group, but hardly enough to be significant. The data for the thyroid and thymus glands were not significant.

While we feel that such experiments as we have described are not conclusive, still the fact remains that a significant difference does exist, for some reason, in the maturation of the testes, between the two groups of animals in one of these experiments. We feel that the conclusion to be drawn from these experiments is that the variables are too numerous to properly control, and yet it seems quite definite that there are several fundamental questions involved in this work which should be given further study. No doubt the same type of criticism might be offered to several of the observations dealing with the many studies on climate and health, but for the present, at least, it would seem that further progress may best be made with these problems by studying them with the experimental method in animals. That there is much to be learned is indicated by the promising suggestions which have resulted from such investigations so far.

Following Huntington's thesis that human energy is affected by the variability of the weather Mills has been engaged during the past few years in studies attempting to link up climatic features with definite disease processes. The observations by this investigator are suggestive of climatic influences in such conditions as heat stroke, acute nephritis, diabetes mellitus, death rates from pernicious anemia, exophthalmic goiter, Addison's disease and angina pectoris. Mills has stated that human fertility is highest in a given population at a temperature of about 65° F., and that it is reduced during the low temperatures of the northern winter and by mean temperatures above 70° F. In a recent paper he has pointed out certain dangers to southerners in northward migrations due to climatic changes. These are stimulating observations by Mills and they are certainly suggestive. When and if the experimental method may be applied to some of these interesting problems they will no doubt be accepted with greater favor and interest by biologists.

Reed lists some twenty factors in his study of medical geography in the tropics. This author goes so far as to include religion and politics among these and states that "health is a balance obtaining between the life principle as exemplified in man, and the sum total of his environment." He feels that a new era in medical science is taking us rapidly into a field which can be termed medical geography. In this we would certainly agree.

Reed has mentioned one factor, namely, food and diet, which we feel

deserves further comment in relation to the question of climate and health. It would matter little what the climate is if man is without proper food. Food supply is, in turn, directly related to climate, and it is our considered opinion that too often the factor of nutrition is given too little attention while climatic factors are perhaps given too much. Of the two nutrition would seem to be the more important and, without question, this factor, and others as well, may frequently complicate studies designed to determine the effects of climate on the living organism. It is highly important then that the element of nutrition be well controlled and understood in all studies dealing with health.

In conclusion we feel constrained to insist that, despite the present chaotic state of our knowledge in this field of climate and health, there is indeed in this subject a significant realm of thought for future experimentation. A few pioneers have blazed the trail up to this point with inadequate facilities and little support, but many suggestive and interesting lines of attack have been brought to light. Future developments in our civilization will no doubt focus greater attention upon these problems, and the golden reward which awaits man in his social, economic and physical life, following their solution, should further enrich scientific knowledge and all the peoples of the world.

THE DARK GALAXY

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THE question is often asked whether among the myriads of shining stars there are not numerous dark bodies or planets as well as smaller pieces of non-luminous material in the vast interstellar spaces. Our experience on the earth, as each hour we sweep up only a few meteors as the earth travels thousands of miles in its motion about the sun, would lead us to infer that space as a rule is fairly empty, but our solar region may not be typical.

If there are dark planets connected with other stars, we have no means of finding them. In the thousands of close double stars, the smaller bodies are, so far as we know, always self-luminous, and as a rule they are far more massive than any of the sun's attendants. Small planets revolving about the stars, or even bodies larger than Jupiter, are quite out of our reach. Moreover, so great are the distances between the stars as compared with their diameters that for every luminous body in sight there could be many dark objects of comparable size without our being aware of their presence.

OBSCURATION POWER OF DUST

It is only when material between the stars takes the form of small particles like gas or dust that we are likely to detect its presence from the obstruction of light. If a solid body is broken up into similarly shaped pieces each half the diameter of the original, there will be eight new objects each with a quarter of

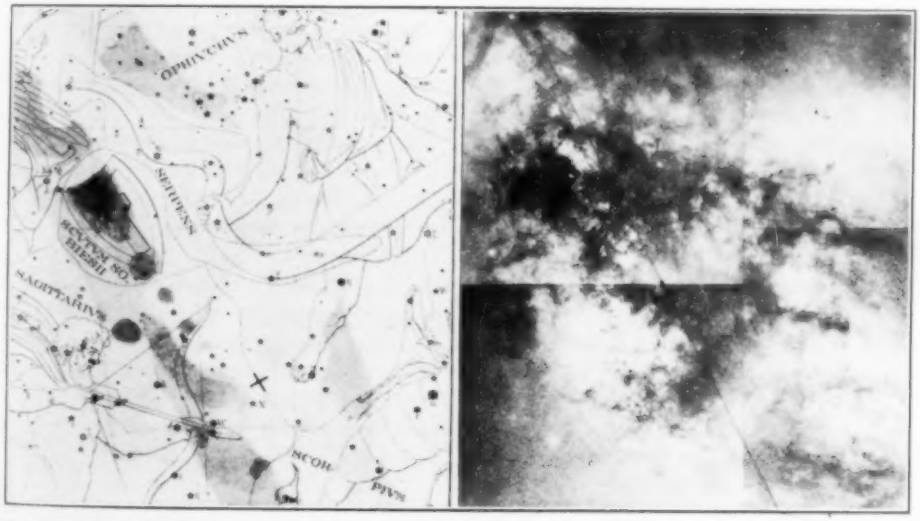

FIG. 1. LEFT: STAR MAP SHOWING TWO BRANCHES OF THE MILKY WAY IN THE REGION OF THE CENTER OF THE GALAXY, WHICH IS MARKED BY THE CROSS. RIGHT: MOSAIC PHOTOGRAPH BY ROSS, SHOWING STAR CLOUDS AND OBSCURED REGIONS NEAR THE CENTER OF THE GALAXY.

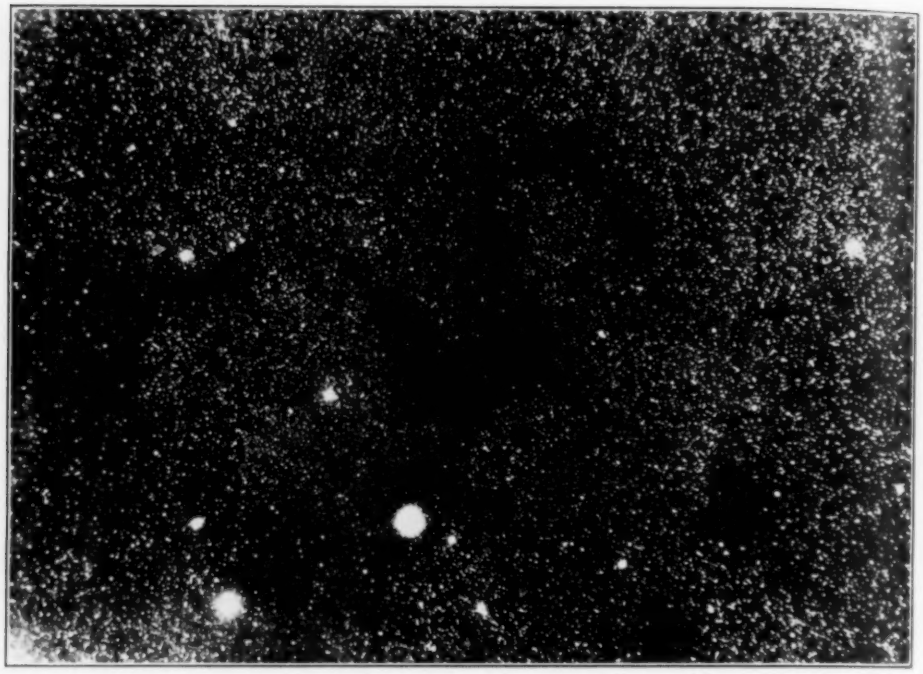

FIG. 2. DARK AREAS IN THE MILKY WAY.

the surface of the first body, but having a total of double the area or occulting power. Similarly, if a star a million miles in diameter were divided into globes each one mile across, the increase in surface would be a million fold. Another division by a million in the linear scale would give particles comparable with coarse sand, and a further division by one hundred would give dust particles of a diameter about 1/600 centimeter. Counting up the factors we have $10^6 \times 10^6 \times 10^2 = 10^{14}$ as the increase of surface area produced by pulverizing a solid body the size of a star down to the consistency of fine dust.

The number of individual stars that can be seen or photographed with present telescopes does not much exceed 10^{10}, so with due allowance for the gaseous state of the hot stars we have the rather striking inference that if a single body like the sun were broken up and distributed around in space in the form of fine dust, the obstructing power of this matter would be greater than that of all the stars in sight. Therefore, if light from certain parts of the sky seems to be obstructed, the screen or curtain which blocks our view is more likely to be a mass of small particles than a clustering of stars.

The simple geometrical consideration of the obstruction of light by different-sized bodies holds only so long as the particles are large compared with the wave-length of light. There is a range from a given limit down to the dimensions of molecules, call it between 10^{-5} and 10^{-8} centimeters, where the action of particles is to scatter in all directions the light which falls upon them, rather than to obstruct or reflect it back toward the source.

The amount of this so-called Rayleigh scattering depends upon the color—strictly, it varies as the inverse fourth power of the wave-length—and it is made evident to us in the blue color of the sky. When we see the sun reddened

FIG. 3. N.G.C. 891. A SPIRAL NEBULA OR GALAXY SEEN EDGEWISE.

near the horizon due to the longer path of the light through the atmosphere, the blue light which has been taken away from our direct perception has contributed to the color of the sky somewhere else. Likewise if between us and a distant star there are a sufficient number of gas or dust particles of the size that produces scattering rather than obstruction, we shall find a certain space reddening of the light coming to us, just as we do for the sun at sunset. In the process of either obstruction or scattering there is what we may call absorption, as the observer receives less light than he would if space were empty.

Evidence of Dark Material

There is strong enough evidence of dark material or dust in our stellar system. In Fig. 1 (left) are shown portions of the Milky Way as it is represented on a star map. The two branches, one of which almost fades out, were formerly attributed to the arrangement of clouds of stars, but it is now universally agreed that the division is due to a widespread obstruction of light in space.

The combined photographs in Fig. 1 (right) give a better idea of this region of the sky than can be had by direct vision on a clear dark night. It must be more than a mere coincidence that the center of our galactic system, determined from positions and motions of many stars, should be just in the general direction where the Milky Way is divided, and where the evidence of dark material is most conspicuous. It may not be true that the rounded bulge of obscuration about the position of the center marks a dark kernel of our system, but at least there is no other region in the sky where the appearance gives such a strong suggestion of a nucleus.

At first glance it is not easy to distinguish between spaces which are between clouds of stars and the real effect of absorption, but any hesitancy that we have in accepting the presence of dark mate-

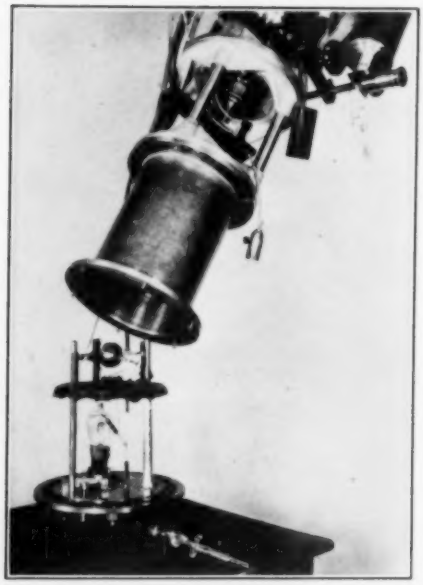

FIG. 4. THE PHOTOELECTRIC AMPLIFIER ATTACHED TO THE 15-INCH REFRACTOR.

rial is overcome by the appearance of such regions as that in Fig. 2, which is a much larger photograph of the first bright area to the right or west of the center in Fig. 1 (right). The conspicuous S-shaped affair, and smaller attendants, from their very appearance give the impression of complete obscuration. In many places the edges of the black spots are too sharp for it to be plausible that we are looking along holes or vacancies out to where there are no more stars. There is often the complication of stars in the foreground, and we have to do the best we can in conceiving of a simple model of the stellar system when stars and dark stuff are promiscuously intermingled.

We are in much the same position as one bee in a swarm trying to make out some order of arrangement in the neighborhood: there is always the interference of the foreground companions. Our bee would get a better idea of his own swarm by looking completely outside for another swarm. We too can get some hints of our own galaxy by scrutinizing an external nebula as in Fig. 3.

Consider the appearance of the heavens to an observer placed in the median plane of such a system and say two thirds of the distance out from the center to the edge. He would have a band of light or Milky Way extending all around his sky, and in one direction, toward the center, this band could well be divided lengthwise by a dark region. The conception of the nebulæ being systems of stars like our galaxy is now universal, and we may fix the idea by learning the astronomical multiplication table, "A thousand million stars make one galaxy; a thousand million galaxies make one universe."

Since there are many other flattened galaxies which show dark streaks down the middle, the evidence of possible absorbing material in other systems is wide-spread. Thus far, however, we have considered only the obstruction of light that is unaccompanied by scattering. The stars which we barely see through clouds of fine dust ought to be reddened, and we may digress to consider the means which have been developed to detect such a change of color if it exists.

The Photoelectric Amplifier

As supplements to the eye and photographic plate various physical instruments have been developed, among which is the photoelectric cell. This well-known device has been increasingly used in recent years; in fact, it has been well said that the applications of the photoelectric cell are limited only by the imagination of the experimenter. Such cells have been known in the laboratory for half a century, but now we have their everyday use in talking pictures and television, for sorting or shading beans, buttons or cigars, for counting automobiles and pedestrians, for burglar alarms, for stopping or starting anything, even up to the World's Fair, and finally for measuring the Milky Way.

It was the advent of the thermionic vacuum tube as developed for the radio that made possible the use of the extremely minute current which is generated in a photoelectric cell when exposed to faint light. Such a combination of cell and tube for use on a telescope is shown in Fig. 4.

For many years the cells produced by Dr. Jakob Kunz, of the University of Illinois, have been applied to stellar photometry, the measuring instrument for the current being hitherto some form of electrometer. The improved installation with cell and tube, mounted inside a tank from which the air is exhausted, as perfected by Dr. Albert E. Whitford at the Washburn Observatory, is considerably more stable and sensitive than previous forms of the photometer.

An indication of the sensitivity of this so-called photoelectric amplifier is given by some tests made at Madison. The instrument was detached from the telescope and directed to an ordinary candle set up a mile distant across Lake Mendota. With an exposure to this light the amplified photoelectric current caused a deflection of over 150 millimeters on the scale of the galvanometer, which was repeated at will with a probable error of less than 2 per cent. With the incident light reduced some fifty-fold the deflections were about 3 millimeters and the probable error only about 0.2 mm. By actual test the amplifier has thus easily shown the presence of a light equivalent to a candle at seven miles distance, farther than it can be seen by the eye; and the calculated limit of detection was a candle at about 30 miles, neglecting of course the effect of absorption by the air beyond the first mile which was actually observed.

As the window of the photoelectric cell was just one inch in diameter, it is easily verified that the factor of increased power of the amplifier attached to a telescope is given simply by the aperture of the objective in inches.

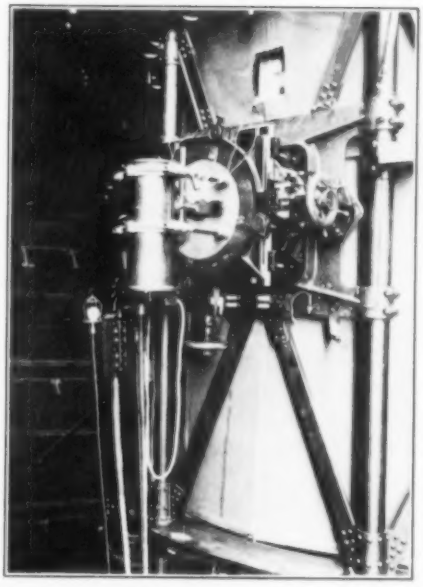

FIG. 5. THE AMPLIFIER AT THE NEWTONIAN FOCUS OF THE 100-INCH REFLECTOR.

Thus the installation on our 15-inch refractor would reach a candle at 450 miles, while with the 100-inch reflector the limit would be extended to 3,000 miles. Experience has shown that this degree of sensitivity can be maintained in practical working conditions for months at a time.

The installation of the amplifier at the upper or Newtonian focus of the 100-inch reflector at Mount Wilson is shown in Fig. 5. For a star or nebula the total light can be determined, and then by insertion of suitable filters the spectral intensities in the blue and yellow regions are compared, giving a measure of the apparent color or the degree of reddening of the object. The operation of the amplifier on the large telescope is a three-man affair, requiring the regular night assistant to point to the selected region of the sky by means of the divided circles, one observer to identify the field, pick up the individual object, make the exposures, etc., and another to read the deflections of the galvanometer, located

solidly at the base of the mounting and connected with the moving end of the telescope by some 120 feet of flexible cable.

Our Galactic System

With this digression as to methods of observation we return to considerations of the galaxy. The present conception of the general Milky Way system or galaxy to which the sun belongs is that of a very flattened watch-shaped system (Fig. 6), with which are connected the outlying globular clusters some 93 in number, but the arrangement of the clusters is nearly spherical in form. Each globular cluster is a system on its own account and comprises thousands of stars (Fig. 9a). Just why our galaxy should consist of the flattened main

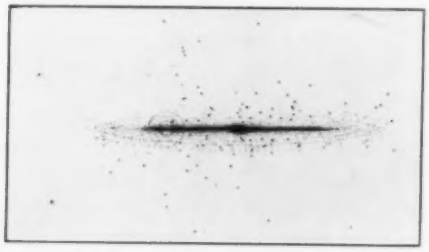

FIG. 6. THE GALAXY, AFTER OORT.
THE SUN IS AT THE CENTER OF THE CIRCLES; THE RADIUS OF THE OUTER CIRCLE IS 8,000 LIGHT YEARS, A THOUSAND TIMES THE DISTANCE FROM THE SUN TO SIRIUS. THE LARGER DOTS REPRESENT GLOBULAR CLUSTERS.

group of stars with the related more dispersed system of globular clusters is not understood, but Hubble has found more than one hundred objects, tentatively identified as globular clusters, in much the same relation with the Andromeda nebula.

The sun is placed at a considerable distance out from the center of the galaxy, at the center of the small circles drawn in Fig. 6. Because of our immersion in the mass of stars the extent of the system is not easy to determine, and is still a matter of discussion among astronomers. We are probably able to see very few individual stars beyond the galactic center; in the median plane it is very doubtful whether our range extends even as far as the nucleus, and the overall dimensions have been inferred from Shapley's determination of the general system of the globular clusters.

Perhaps a fair estimate of the current notions of the diameter of the main part of the galaxy is 80,000 to 100,000 light years, though in the opinion of the present writer this figure is more likely to be reduced than increased. All distances inferred from the apparent brightness of objects of assumed intrinsic luminosity are affected by absorption of light in space, and it is just in the direction of the galactic center and beyond that this absorption is most conspicuous.

If we consider an observer near the sun studying the arrangement of stars at successive steps of increasing distance, as indicated by the concentric circles in Fig. 6, then as the stars become apparently fainter they would be distributed in narrower bands agreeing roughly with the position of the Milky Way. A selection of uniform stars is furnished by the B-stars of the Harvard classification. These objects, sometimes also called Orion stars from their prevalence among the bright stars in the constellation of that name, are among the hottest and brightest known.

Their intrinsic luminosities range from 500 to 1,500 times that of the sun, and hence they may be seen at great distances. Fortunately, also, their spectra are relatively simple, without the complicating effect of many strong dark lines or bands to cause abnormalities of color. At Madison we have recently completed a study of some 700 B-stars, all those brighter than visual magnitude 7.5 which could be reached in the northern sky.

Measures of the colors of these stars were made by Dr. C. M. Huffer and myself with a photoelectric cell attached to the 15-inch refractor. The idea at first

was to compare the colors of B-stars in pairs or small groups, taking one or more objects within an obscured region, and then others not far away where the stars were apparently more numerous. Any scattering of light by small particles in the spaces of the dark region would show up as a reddening of the partially obscured stars. This test was found not to work out so simply, as all the stars in a large region of the sky were likely to be found to be affected. As the work progressed the observers became aware that any strongly reddened B-star was almost certain to be close to the apparent central line of the Milky Way, usually within two or three degrees of the so-called galactic equator.

The results of the color measures of B-stars are charted in Figs. 7 and 8,

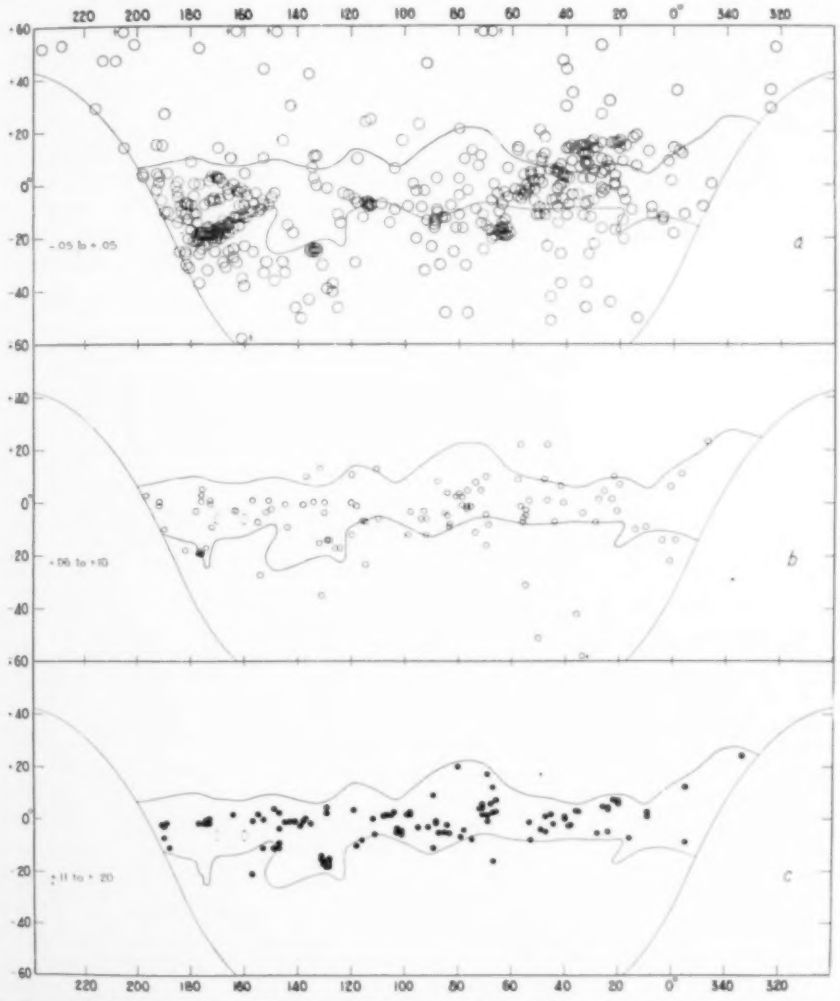

FIG. 7. COLORS OF B-STARS CHARGED ACCORDING TO GALACTIC LATITUDE AND LONGITUDE.

STARS OF NORMAL COLOR ARE REPRESENTED BY OPEN CIRCLES; REDDENED STARS BY BLACK CIRCLES. THE IRREGULAR OUTLINES MARK THE LIMITS BETWEEN WHICH NO OUTSIDE NEBULA CAN BE SEEN.

with the convention that the redder the star the larger is the black circle to represent it. As might be expected the extreme cases of coloration are found among the most distant or faintest stars, and from the form of the galaxy these are likely to appear at small angular distances from the median plane. The limits of the zone where Hubble finds practically no extra-galactic nebulae mark the region where we can not see out, so to speak, and it is in just this part of the sky where the coloring effect is found in the B-stars. It should be noted that Hubble's limits extend north and south many degrees from the middle line, and hence include not only the dark obscuring division but the whole bright band of the Milky Way and even areas beyond.

At longitudes 160° and 170°, roughly opposite the galactic center, Hubble has found two regions where a few nebulae can be detected on the photographs. That these places are "holes" with less absorbing or scattering material is confirmed by the fact that no strongly-colored B-stars have been found near the regions, even when the observations are carried to fainter magnitudes with the reflectors at Mount Wilson.

Study of Coloration

Although we learn from groups like the Pleiades, containing many stars at approximately the same distance from us, that there are wide variations in the intrinsic luminosities of stars having similar spectra, we can still get fair mean distances by averaging many stars, and

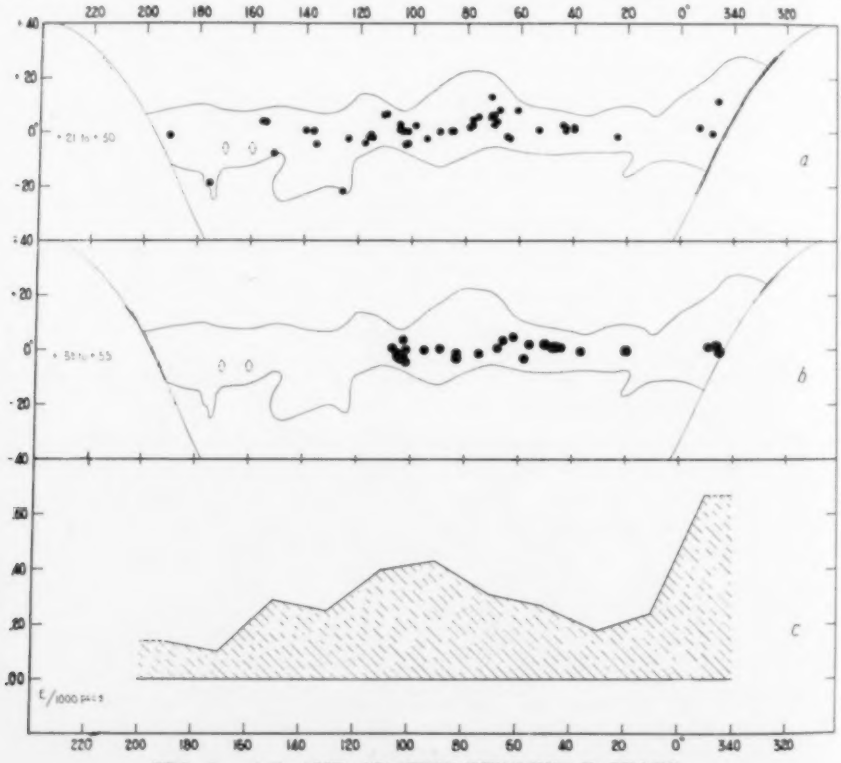

FIG. 8. (*A*) AND (*B*) THE REDDEST B-STARS.
SMALL ABSORPTION AT LONGITUDES GREATER THAN 110°, WITH "HOLES" AT 160° AND 170°.
(*C*) DENSITY OF THE DARK MATERIAL IN DIFFERENT DIRECTIONS, WITH MAXIMUM NEAR THE GALACTIC CENTER AT 330°.

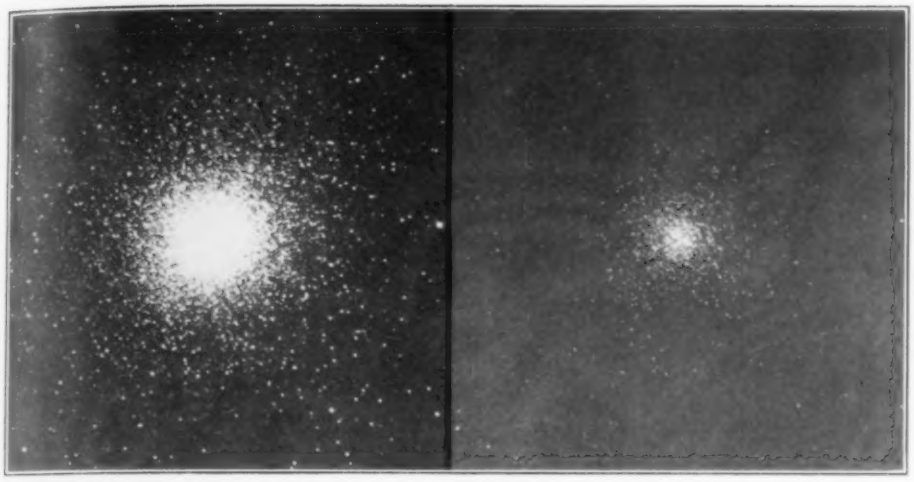

FIG. 9. (*A*) AND (*B*) TWO EXPOSURES IN RATIO 16 TO 1 ON THE SAME GLOBULAR CLUSTER

SHOWING HYPOTHETICAL ABSORPTION OF 3 MAGNITUDES BY INTERVENING DARK MATERIAL.

in this fashion the amount of coloration per unit distance has been derived as is shown in the last diagram of Fig. 8.

The technical quantity, E/1000 pscs = Color-excess per thousand parsecs, is the measure of the amount of space-reddening in a distance of 3,000 light years. The diagram shows a maximum of color effect on the stars near the galactic center in Sagittarius, longitude 330°, with much less reddening in longitudes 120° to 200°—which include the winter constellations from Auriga to near Canis Major. Other observed differences in the amount of coloring are undoubtedly real, but the results may be affected by the lower limit of brightness to which the stars were observed.

The B-stars were chosen for tests of coloration because of their great luminosities, but the globular clusters, each with tens of thousands of stars, can be observed at distances many times greater than the individual stars. In fact, with the amplifier on the 100-inch telescope all the recognized globular clusters visible from the latitude of Mount Wilson can be measured satisfactorily for total light and color, as they are all brighter than the thirteenth magnitude while the instrument will reach to the fifteenth.

Though the composite color of the many stars in a globular cluster is not so definite a thing as the color of a single star, the effective ratio of blue to yellow for the different clusters corresponds to their average spectrum, which is of solar type, and it is found just as for the B-stars that clusters in high galactic latitudes are of normal hue, while those apparently near or in the Milky Way are strongly reddened. The greatest effect thus far found is illustrated in Fig. 9a and b, where the reddening is shown to correspond to a total absorption of 3 magnitudes or of 15/16 of the visual light of the cluster. The real distance of a cluster with this degree of absorption is only one fourth as great as would be inferred from the apparent brightness of stars of standard luminosity found within its borders.

The most colored B-stars which we have found in the Milky Way indicate an absorption of two stellar magnitudes, giving the factor 2.5 for the reduction of their computed distances. If obscuring effects of this size are evident in B-stars only 2,000 or 3,000 light-years from the sun, it would seem that objects still more distant along the median galactic plane

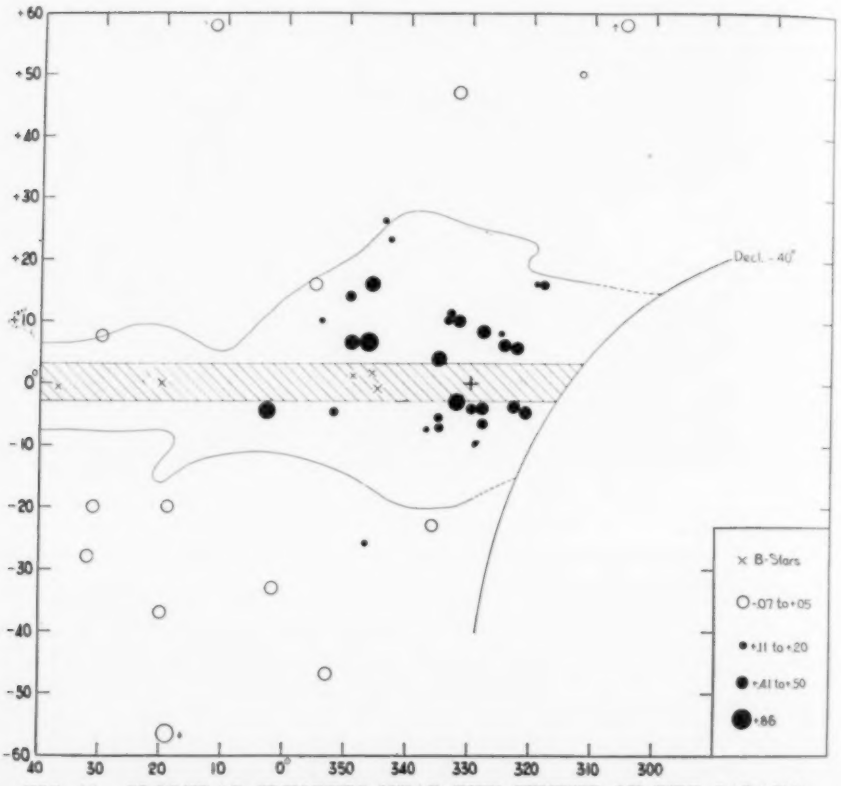

FIG. 10. GLOBULAR CLUSTERS NEAR THE CENTER OF THE GALAXY.
THE BLACK CIRCLES INDICATE INCREASED REDDENING IN LOW LATITUDE, WITH COMPLETE ABSENCE OF CLUSTERS IN THE SHADED ZONE. THE CROSS FOR THE CENTER IS THE SAME SIZE AS IN FIG. 1 LEFT AND RIGHT.

would be red enough to be quite striking to the eye.

Actually this is the case: we have often recognized a faint B-star with the 100-inch by its yellow if not ruddy color. The maximum effect would be to change the white of a star like Rigel to about the yellow of Arcturus. In the globular clusters, however, the individual stars are so faint and the combined glow so feeble, even in the field of the large reflector, that the red color, though conspicuous with the cell, is not apparent to the eye. In Fig. 10 are charted the clusters near the galactic center, observable at Mount Wilson but too low at Madison.

Conspicuous on the diagram are the widened bulge of Hubble's limits about the nucleus of the galaxy, the strong effect of space-reddening for clusters in low latitude, and the complete absence of globular clusters in a zone about seven degrees wide extending along the galactic equator. This significant and well-known absence of the clusters from the middle line is commonly ascribed to an absorption effect. Any other explanation seems forced, and the increased color of the clusters on the margin of the zone fits in perfectly with this idea.

THE DARK FILLING OF OUR GALAXY

It is probable that very few people have looked up in the southern sky on a summer's night and consciously said to

themselves, "There is the center of the galaxy." Even astronomers were reluctant to think of the Milky Way system being like one of the spiral nebulae, because there was no nucleus in sight. The trouble was that they were looking for something too small and too bright. The bulge of the nucleus, marked by the limits in Fig. 10, is some forty-five degrees across; it would extend half way from the horizon to the zenith, and photographs can show only part of the region on one plate.

Also the ordinary reproductions of negatives of the Milky Way and of the nebulae give an exaggerated impression of the surface brightness of the objects in the sky. The exposures of the plates of Fig. 1 (right) were about four hours, and of Fig. 3, seven hours. When seen directly through the telescope such nebulae are disappointingly faint. With all this in mind, the resemblance of the division of the Milky Way to the corresponding appearance of some of the nebulae is very striking to the naked eye, under the favorable conditions of a dark sky.

The conception of the appearance of our galaxy from the outside as a round flattened system with a dark region down the middle is well exemplified by the object in Fig. 11. The general form of the system has often been likened to that of a watch or bun, but perhaps it is better to change the figure to a "ham sandwich" to allow for the dark filling; and we are in the midst of the "ham." It should be remembered, however, that the stars do not thin out near the main plane; in fact, that is the region where they are probably thickest.

The presence of a thin absorbing layer of dark material concentrated near the middle of the galaxy, not more than a few hundred light years in thickness, was first emphasized by Trumpler from his studies of open clusters of stars distributed near the galactic plane. The work with the photoelectric cell has confirmed and extended his results.

In addition to the material which

FIG. 11. THE NEBULA N.G.C. 4594.
ANOTHER GALAXY IN THE FORM OF A "HAM SANDWICH."

shuts out stars in the Milky Way, we now have ample evidences of smaller particles which give selective scattering near the same regions, but the picture is still incomplete. There is another whole dark galaxy or cloud in space, composed not of solid particles, but of atoms, largely ionized atoms of calcium. Where the large dust particles obstruct the light and the smaller ones scatter it, the calcium atoms produce only the selective absorption of a few lines in the spectra of stars seen through the cloud.

Here again the B-stars are the best objects for the tests, partly because of their great luminosity, but particularly because there are few or no atoms in their atmospheres that are producing the dark lines caused by the interstellar calcium. The lines in the spectra of B-stars have been used by Plaskett and Pearce to demonstrate that the calcium cloud partakes in the rotation of the galaxy about the same center in Sagittarius that is marked by the motions of the stars themselves.

There is one outstanding discrepancy, namely, that the B-stars with intense lines of interstellar calcium are not the stars that we find to be strongly reddened. We should naturally expect the stuff between the stars to be mixed up pretty well together, but this is apparently not the case. This lack of correlation between space reddening and calcium absorption has also been found by Elvey and Struve in photometric and spectroscopic observations of the same stars taken at Yerkes Observatory.

Just why this lack of agreement should exist is at present a puzzle, but it is probably not due to errors of observa-

FIG. 12. (*A*) REGION OF THE ANDROMEDA NEBULA, PHOTOGRAPHED BY BARNARD WITH THE 10-INCH BRUCE TELESCOPE.

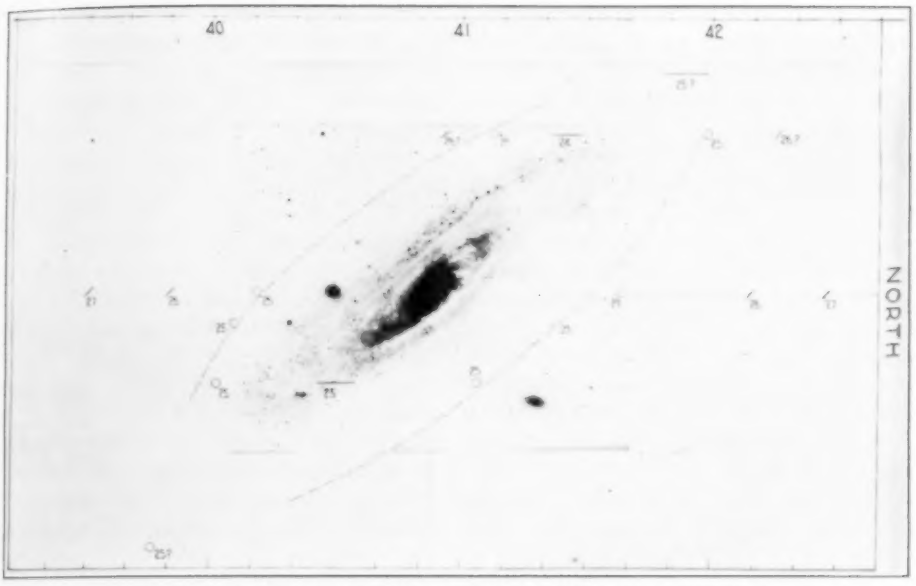

FIG. 12. (*B*) EXTENSION OF THE ANDROMEDA NEBULA.
THE NUMBERS GIVEN THE MEASURED INTENSITIES IN STELLAR MAGNITUDE PER SQUARE SECOND OF ARC. THE NEBULA IS 40 TIMES FAINTER AT 27 THAN AT 23. (NEGATIVE BY RITCHEY).

tion. There is some evidence that the calcium cloud is not as much condensed in a thin layer as the scattering dust, for when the B-stars are charted according to the intensity of the calcium lines, in diagrams similar to Figs. 7 and 8, the stars with strong absorption are much more widely dispersed in latitude. Taken altogether, the stuff between the stars, which is becoming increasingly evident, probably is of total mass as great or even greater than that of the stars themselves. The dark galaxy may turn out to be the major part of our system.

LIGHT INTENSITIES OF NEBULAE

The one difficulty with considering the Milky Way system as a galaxy similar to the numerous nebulae is that of size. The comparison is easiest made with a near and large object like the Andromeda nebula (Fig. 12a). From the apparent brightness of Cepheid variable stars, novae and other objects in this nebula, the distance is calculated to be about 800,000 light years, and from the apparent extent on the photographs the diameter is some 40,000 light years. With the galaxy 200,000 light years across, the discrepancy in the linear dimensions of the two systems was about five to one, but with allowance for the effect of dark material on the inferred extent of our own system we can bring the ratio down to two or three to one.

This nebula is far enough from the Milky Way so that we see it through only a small amount of absorbing dust, and hence its computed dimensions are but slightly affected, but if we could find that the nebula extends out farther than the pictures show, the difference between our galaxy and the nebula would be still further reduced. With this test in mind an effort was made by Dr. Whitford and myself during the past summer to measure the light of outlying regions of the nebula with the installation at Mount Wilson.

We are likely to forget that the limit for faint stars and nebulae that can be

reached by the eye, or especially by photography, is set not so much by the size of the instrument as by the diffuse light of the sky. Even on the darkest night at a mountain station there is a faint glow in the atmosphere, due largely to a permanent aurora, which exceeds the light from the stars. Otherwise the exposure of four hours for such a picture as Fig. 12a could be forty or even four hundred hours. For telescopes like the reflectors with focal ratio f:5, an exposure of four or five hours is about as much as is advantageous; any additional time will produce simply more blackening of the plate from the general light of the sky.

In measuring the Andromeda nebula with the photoelectric cell the procedure was to compare the light of small areas near the nebula with regions of the sky several degrees distant. The galvanometer deflections were recorded at intervals along a north and south circle, and on subtraction of the mean deflection for sky alone, given by the outermost readings, from other deflections of sky plus nebula, the residual effects for the nebula were determined.

The results are charted in Fig. 12b, where the small circles marked 25 indicate to scale the area of sky measured, and are placed about the nebula where the intensity was found to be equivalent to stellar magnitude 25 per square second of arc. As the light of the sky alone was about 22.3 mag./sq. sec. it follows that the nebula at these points was only 1/12 as bright as the sky foreground, and similarly for magnitudes 26 and 27, as marked, the ratios of nebula to sky were 1/30 and 1/75, respectively.

In this method the cell can detect about 1 per cent. of the sky brightness, the limit being placed by stars in the field too faint for the observer to see when selecting regions for measurement. A definitive comparison of the sensitivity of the amplifier and the photographic plate has not been made, but it is known that the photographic limit for threshold images is about 25 mag./sq. sec., so the cell seems to be several times the more sensitive.

The rough outline of the nebula for intensity 25 is shown by the broken line of Fig. 12b, and even this intensity is beyond the limits of the photograph. A study of the regions along the apparent major axis of the nebula has not been completed, but in the areas measured the extension is at least double that shown on photographs. We may, therefore, anticipate that the overall diameter of this neighboring galaxy will turn out to be 80,000 light years instead of 40,000.

Other measures in and about the nebula give us a comparison with our own system. According to Seares, the surface brightness of the galaxy viewed from outside and in a direction at right angles to the main galactic plane would be 23.7 mag./sq. sec. This brightness is barely visible on the photograph of Andromeda, the central part of which is about 100 times brighter than the sun's region of the galaxy.

Just how bright our own system may be near the nucleus is difficult to estimate because of the dark material in that direction. The little circle at 25 mag./sq. sec. for Andromeda encompasses the light equivalent to 110,000 suns, and out at 27 on the diagram the figure is nearly 20,000.

At the center this same sized area includes about 75,000,000 suns, a figure large enough to raise the question whether so many stars could be packed in so small an area without some being in front of others. A simple calculation, however, will relieve us on that score. If our line of sight in the direction of the nucleus of the nebula would always hit the surface of a star, then this part of the nebula would appear to us as a brilliant object with the surface intensity of the sun. Actually this surface

brightness is 28 stellar magnitudes fainter than that of the sun, and it follows that the apparent spaces between the objects are 1.6×10^{11} times the area of the stars themselves. Thus there is still plenty of room between them.

Our Galaxy Predominant in Size

The nebula of Andromeda with its billion or more stars is one of the largest, if not the largest nebula, in sight. Perhaps the two companion objects in the photograph, apparently attendant nebulae, are more nearly typical of distant galaxies, but the main nebula is a close rival to our galactic system. In fact, the largest estimates for the Andromeda nebula exceed the moderate guesses for the galaxy. Lundmark places the nebula at about 1,500,000 light-years distance, which with the revised apparent diameter gives a real diameter of more than 150,000 light-years, or half again the size of the Milky Way system. The photoelectric cell has contributed to this comparison by helping to enlarge the nebula, and to decrease the estimate for the galaxy. Nevertheless, even with the uncertainty of dimensions in our own neighborhood, the galaxy still stands out as a continent among the islands, but not as great a continent nor the only one, as was formerly supposed.

Long ago men thought that the center of things was near the eastern end of the Mediterranean Sea. As the world grew larger it became a sphere, with other planets and the sun and stars revolving about the earth. Centuries were required to move the center from the earth to the sun, and only recently have we taken the sun away from the middle of the stellar system. Now we may have our proper place, but characteristically our own galaxy is predominant, surpassing everything else in size and importance. It is difficult to make the step, but ultimately we shall probably come to the conclusion that we live in just another galaxy, that's all.

THE DOMESTICATION OF ANIMALS

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Introduction

The domestication of animals holds an important place in the list of great things that mark the progress of man. Coinciding with the culmination of man's essays that led to planting, there are seen in rearing and agriculture the founding of two great bases of civilization.

There appear to have been three great phases of human experience with animals: (1) Animals as human congeners; (2) man as distinct from other animals; (3) animals selected and controlled by domestication.

Another may come in the invention of economic forms of animals. The first period extends over the whole time, including man's origin and development to the transition to the Neolithic. We know little more than that in the course of this long formative period there was a succession of animals appropriate to climatic periods of the glacial ages and long extinct.

The second period reveals what amounts to a revolution in human history in the Neolithic and its preparatory phases. Up to this time there was little hope that the genus Homo would achieve a notable destiny. In a few thousand years the indices of civilization were fixed. Man had separated widely in word, thought and deed from his animal roots and assumed his captaincy of nature. For helpers he began to domesticate animals, taking them out of their natural limits, changing their habits and otherwise adapting them to his own use.

Previously, we view man as still enmeshed with nature, his subsistence natural and his arts in stone, and environmental substances almost exclusively devoted to the capture of food animals. Suddenly, if the word is allowable, tribes that had incubated in a favored area in Asia after the close of the Glacial Period found themselves capable of purposeful migration, with all this implies as to advance and spread of culture.

These tribes swept into Europe and established there the Neolithic. This period is characterized by agriculture, domestication of animals, house building, village aggregations, pottery, wood, advanced utilization of fire, together with other arts. The Neolithic peoples brought with them the familiar domestic animals which we have inherited from them. It appears clear that these peoples domesticated animals at an early period, supposedly before 6000 B. C.

Association of Man and Animals

Domestication of animals is the culmination of a long series of experiences with various types of herbivorous mammals and of birds. The early domesticators learned of the particular qualifications that would lend themselves to the subjugation of species amenable to discipline.

The inference is that man, closely connected with animal life in his early stages, would acquire a complete fund of knowledge of the habits and psychology of his wild congeners. Such knowledge was a part of his useful, even essential woodcraft. The nature of animals guided him in attack and capture. Subsistence was the prime necessity leading man to prey on animals valuable for meat. The animals would be gregarious, numerous, and ranging in an environment suitable for hunting. These conditions are met with in the equidae and

bovidae. Without doubt these herbivores supplied the species that eventually would become domesticated.

Undoubtedly, however, these large animals would in the growth of man's culture come under domestication later than smaller mammals as the goat and pig, and perhaps domestic birds, as ducks and geese.

On the flanks of the wild herds we picture man pursuing the tactics of the primitive time—cutting out stray animals, dogies or bogged cattle as he could, keeping within the range of his prey. The seasonal forage migrations of the animals enforced man's migrations. These were not controlled until later, as in the story "Grass," which is a picture of the early herders transferring their flocks over the mountains.

The chief condition of herd existence is movement. The exigencies of delay in regard to parturition are set off by the short period of helplessness of the calf. Observation shows that in this state it is only a few hours until the calf can follow its mother. The calf soon acquires swiftness and it requires a speedy horse to keep up with a vigorous specimen.

All the evidence points out that the herder stage antedates all other regulated contacts of man with domesticable animals. It is logical here to rehabilitate the hunter stage of the older writers, but it must be said that the latter stage was not applicable as a concept of a form of life in all environments. The roots of agriculture and animal husbandry are quite distinct; the presence of animals as an adjunct of agriculture is a later condition in the latter industry. As suggested, herding is the older industry and, like agriculture, continues as a separate occupation pursued by an important section of the human race to this day.

The natural preparation of animals for domestication represents a long course of evolution. The ordering of mammals into carnivora, herbivora and other classes is the result of evolution in a general sense, connoting the results of a process of life phenomena not as yet understood.

On the entry of man into the animal enclave as one of the products of evolution we must place him in relation with the animal groups that it is his destiny to ward off, regulate and conquer. Whatever was the condition of the animal kingdom before man began his course, the changes since have been great. In some areas the changes have been prodigious and rapid compared with slow-moving nature.

Domestication

In treating of the origin of domestication it will be seen at once that the subject involves the distribution of man and domesticable animals, man's phase of culture, his adaptation for the art, embracing the psychology of the animals, and of man himself, and other lines for consideration.

Considering the major animals of potential use to man, hunting by tribes would precede domestication and would provide a background for future control. There may follow then the herding by pastoral tribes afoot and later with the aid of the dog and horse. At subsequent stages of cultural advance animals were confined within narrow limits by sedentary agricultural tribes utilizing the animal products and especially milk.

It is suggested that the acquisitions of man have been somewhat as follows:

Things near him needful	*Savage*
Things farther away but bounded	*Middle Savage*
Things beyond the rude boundaries	*Early Civilized*
Trade and exploration	*Middle Civilized*
Land ownership and domestication of animals and plants	*Civilized*
Metals, transportation, civil organization, law	*Lower Enlightened*
All arts and education	*Middle Enlightened*
Conquest of forces, thought in higher planes	*Upper Enlightened*

It is evident that man did not domesticate animals until he reached a certain stage of domestication himself. This stage for all races of men is not uniform, but is conditioned by various circumstances, such as the habits of the tribes, the presence of domesticable animals, the regional aspects and the like, and the stage of advance in culture.

The presence of domesticable animals depends on orographic conditions governing the range of such species. These conditions have changed often in human history since the last glacial epoch, placed by Peake and Fleure at about 4000 B. C. The changes have been important enough to regulate the distribution of man and animals over large areas of the Old World.

In general, domestication of useful animals begins when conditions are ripe for the handling and protection of flocks and herds. This, of course, represents a considerable advance in culture by man, and such a state of society is comparatively recent. The knowledge acquired on the art of domesticating animals was long in being brought together out of past experiences.

The date at which domesticated animals occur can not be ascertained with any degree of finality. It is not supposed that domestication took place all at once or in any one region, but it is true that the process was finished in a definite period of man's history. This period is characterized by a considerable human progress, in which appears agriculture, houses, pottery, wars of offense and other evidences of growth in culture.

There is no evidence of domestication of animals in the ages before the Neolithic. Evidence is therefore lost on the handling of harmless animals that may have haunted the environments of early man, as, for example, the pets of the Arawaks and other South American Indians. Commensal animals no doubt existed, such as those that waited on carnivores for a share of the catch. Of these the dog seems to have been early in hovering around the camps of man and perhaps the earliest in coming into domestication; note the skulking of the coyote and jackal.

The response of human society to the utilization of domestic animals varies from quite general to limited. On the one hand are seen herdsmen intimately connected with their flocks, using the soil only for grazing, and the farmer possessing a limited number of animals. These occupations are self-limiting. The herdsman can not tend flocks and till the soil, especially before the advent of fences. He ranges his herds free, following the seasonal growth of feed over the mountains or the plains. There is here no doubt some clew to the origin and development of domestication. There is also ground for the separation of groups of men into pastoral and gregarious.

As to domestication of certain animals at more than one place and time there is some question. There is a tendency of pressure of civilization to limit or draw in animal life. Interference of natural range and capture and confinement may result in domestication. To answer the question of more important domestic animals research must be made on the geographical range of animals and thus their occurrence in localities where domestication was first practised. In this case each animal must be considered.

Of the interval between the domestication of useful animals in the Neolithic and their appearance and their utilization by peoples on the frontiers of history we know little beyond the distribution of such animals. At every advance of this frontier, however, the chief domestic animals are found to accompany the culture of the ancient civilizations using the prime metals.

"The horse was known in Babylonia as early as the time of Hammurabi" (2124–2081 B. C.).[1] Dr. Smith states

[1] Sidney Smith, "Early History of Assyria," pp. 213–214, N. Y., 1930.

that the Babylonians believed that the horse was known as early as 2500 B. C. He also states that the Hurri of Indo-European stock and believers in Hindu gods were great horsemen. This would suggest that the horse came to the west from India.

A picture of primitive man in association with wild cattle is given in the Sumerian epic of Gilgimash. Eukidu, a Sumerian god, was in the beginning a typical savage watering at the springs and feeding with the cattle. When Enkidu was taken into the city and associated with men the wild cattle no longer recognized him, but fled away from him.[2]

A study of the economic animals leads to the surmise that these were brought under domestication in Asia. There is no doubt on this point as to the camel, elephant, yak and water buffalo. These may be considered local domestications of special animals inhabiting special areas. Changes from hunter to pastoral and sedentary life seems to have been less affected by climatic causes in Asia than in Europe. Studies of the domestication lead to Asia as the center of distribution of most of the major domestic animals. The locality where this took place is probably east of the Caspian, known as Eastern Turkistan.

Some suggestions as to the domestication of animals were presented in an article "The Development of Agriculture," published in THE SCIENTIFIC MONTHLY for October, 1929, pp. 301–310, and a more popular account in "The Story of Fire."[3] These referred to contacts of man with animals of various mammal groups whose habits and make-up would put them in line for future domestication.

As set forth, the preparation of the man stem, aiding him to become man, is paralleled in the development of certain herbivorous mammals that subsist on what may be called primary food. These forms entering into domestication have originated by a process of selection. The early stages of this selection, artificially influenced by man and involving submission by the animals, can only be conjectured.

We know, however, that the natural association with wild animals of the Pleistocene was not of a type to foster domestication. The horse, wild cattle and smaller mammals, marked in a sense for domestication, were hunted for meat, skins and other useful products. Their diffusion necessarily was not uniform as to time and area, but the mammals mentioned survived into the age when the circumstances of human culture permitted the application of domestication. At this time the suitability and adaptability of animals for domestication was gauged, as suggested, by the experiences of a long period of association in what has been called the stage of savagery.

The fear that is engendered in animals by happenings out of the ordinary is a protective device. In conditions where, for a period of undetermined length, animals are not subjected to fear the protective device is obliterated, becoming a useless function. Many instances of this have been observed, and their occurrence is noted as extra normal by believers in the tooth and claw order of nature. Observers in new country have recorded with expressions of surprise the lack of fear by animals.

It is true that discharge of firearms, the light and smoke of camp-fires very soon puts an end to an edenic simplicity like this. Fear is displayed, often in an exaggerated degree, and at the same time the animals become educated in evading the dangers. It is seeen that the inventions of man for the capture of animals require increasing refinements to be effective. There is no doubt that most animals are apt students in the school of experience.

[2] Stephen H. Langdon in "Mythology of All Races," vol. 5, The Semites, p. 238, N. Y., 1931.
[3] Doubleday, Doran and Co., p. 27, 1930.

There still remain in remote parts zones of peace where animals are unaccustomed to fear. One such zone was found in Tibet by naturalists on the British Mt. Everest Expedition. In this case the naturalists were permitted to observe the animals, but not to collect or disturb them, these rules being promulgated by the Tibetan authorities. Another instance, not man-controlled, was brought to my attention by Henry B. Collins, Jr., who observed the lack of fear among the birds and animals during his explorations on St. Lawrence Island, Alaska.

The adjustment of tribes of men and the animals in their environment is also noted. The announcement of "plenty of game" is not inconsistent to the presence of population, that is, of natives whose predilections and needs are not those of races called enlightened, who are only satisfied with extermination of the fauna.

The above leads to the generalization that domestication is not the province of cruel and fear-engendering men. Domestication came about in zones of peace and was accomplished by peaceful men through kindly methods.

The coming together of such fortuitous circumstances as such animals suitable for domestication and men of the peaceful, patient type undoubtedly was found in Asia, where our domestic animals originated.

An examination of the degree of domestication of various animals leads to the view that tolerance, semi-domestication and domestication are the classes into which they may be divided. The camel is an example of the first class. The carabao is only semi-domesticated, given to stampedes, is individual and requires care, and on the whole is just tolerant of man.

In general, the care of animals depends on their stage of domestication and also their physiological make-up, psychology and habits.

When man hunted animals there was begun strategy by which numbers could be surrounded. At a later stage this strategy was continued and finally adapted to the taking of animals for domestication. Animals of smaller size, as goats and sheep, being huddle animals, could be cared for more easily than the herd animals ranging over a wide feeding ground. With the herd there was less personal touch than with the sheep, which could be led or controlled by a shepherd.

The handling of the flocks and herds required at the beginning of the industry a knowledge of the habits and reactions of each species. In the controlling of animals we have several appliances of early invention. Mention may be made of fixed adjuncts as fences, corrals, pockets, gates, barns and outhouses. Free adjuncts would be in part lassos, cords, whip, goads, crook, harness and saddles. In handling animals we note nose snubbers and hobbles.

Animal aids also played a prominent part in the control of animals, the dog especially. The horse after its domestication and use for riding was always a most valuable aid in the control of herd animals, though not indispensable, as man has fleetness of foot in a high degree. Other domesticated animals are used to decoy or force in other beasts, as with elephant captors. Sometimes the sex urge is used.

Man has a decided aid in promoting domestication by what may be called the food whip. He has great power in giving and withholding food and water to animals. We do not know when this method of coercion was applied to domestication, but it must have been primary. Captured animals go on a hunger strike, but presently come to accept food from man. By stages the food giving becomes a customary thing and the animal is well on the way to being domesticated. The habit of receiving food be-

comes a part of animal experience and strengthens the dependence on man.

It is observed that stress often softens the wildness of animals, as in the winter the wild elk of Yellowstone Park coming down from the mountains to limited feeding grounds become quite tolerant of man. Drought, fires, storms, earthquakes, cold, heat, overgrazing—all have their problems for animals and give man advantage in beginning domestication.

The killing of feral animals by man with his superior weapons is also seen to be an aid in the amelioration of herd animals. In this respect man has unconsciously paved the way to the art of domestication.

Man with his superior intelligence could take advantage of the hampering of animals by the terrane. It may justifiably admit of supposing that sheep and goats could be captured in pockets in the mountains or during heavy snows.

Many tribes of the world are destitute of domestic animals and are in this respect like the tribes in the early periods before domestic animals were acquired. Notably they were absent in Australia, not even the almost universal dog being found there among the wild tribes. The Negritos of the Philippines had no dog. Negroid Africa was gradually supplied with domestic animals, and even now some tribes have none. Much of the New World possessed only the domesticated dog.

Effects of Domestication

When the art of domestication began it was not realized what rapid evolutionary processes would follow on the animals themselves. The subject of animal variation is of fascinating interest, but can only be mentioned here.

The effects of domestication due to the segregation and working, that is, handling, of animals may have been apparent in a comparatively short time. With increasing knowledge man laid the foundation of animal industry by selection of variations, breeding, castration of unneeded males, separation of age and sex groups, feeding and "working." The industry represents the trial and error of thousands of years and is always with human advance accumulating new knowledge whose bounds no one can predict.

Pets and Tolerated Animals

The adoption of animals as pets offers an interesting chapter, throwing light perhaps on the processes of domestication treated in this paper. The dominance of man over animals, growing more and more from the earliest periods of which we know, would indicate the possession of pets and tolerated animals at almost all periods. The abstraction from the environment of small animals as pets and commensals is usually a temporary matter, and it is likely that for the most part little of economic value ensues. The harboring of pets seems to be a human trait, but is reflected in nature by various contacts of one animal with another.

There is an infinite number of examples of pet domestication, some dating far in the past. Conditions in northwestern South America give rise to the acquisition of many pets. Travelers remark on the number of birds and other animals freely moving about in the palm-thatched communal houses of the Caribs and Arawaks of British Guiana. Hunters in the jungle, armed with bow and blowgun, preserve the silence of the dark forest. The animals are not frightened, as remarked on the preserves in Tibet.

There are many instances where birds are confined for special uses, notably for feathers. The turkey of the Pueblo Indians is not eaten, but is kept as living supply of ceremonially pure feathers and these birds are very tame. The eagle is caged by the Zuni Indians for the same purpose, but this bird is untamable.

It seems that the economically useful

birds, like the chicken, may have been brought into domestication through the pet stage. Eggs are a bird hazard, and where the knowledge of artificial incubation became known domestication was well to the fore.

It seems quite reasonable that the dog at first was a tolerated animal that had attached himself to the camps of man as a consumer of offal. The dog as a hanger-on policed the outskirts, and his primary value was watchfulness and the sounding of an alarm when animals or enemies approached. Gradually, and likely by the pet approach, the dog became closely allied to man. Rightly the general opinion is that the dog was the first domesticated animal. In every stage of man's culture the dog has fitted in an almost indispensable part.

There may be some connection between the feature of animals in cult and domestication. There is no selection on this basis, feral as well as domesticated animals appear in the series. The selecting of cult animals was not a haphazard matter but was influenced primarily by respect for or fear of animals whose qualities were recognized through the ancient contacts. This may give a clew to the origin of animals in cult. It will be seen that the idea of fierceness and strength preponderates in cult animals chosen to this day. Domestic animals in cult have a wide usage—for example, the cow, bull and dog in Egypt.

Clearly the progress of man has been much assisted by the possession of domestic animals. The hampering effect also should be noted, but the counter value in giving man a basis of subsistence and the impedimenta of possession and care of his charges, tending to enforce a more stable method of living, is likewise an important factor in his progress.

In this progress the period at which the correlation of vegetal food and animal meat and milk food tended greatly to foster the well-being of man. This is notable in civic organization, bringing the herder and agriculturist together as elements in the culture complex. The growth of society in regard to the surroundings of domestic animals may be considered as for herdsmen only, many of one or more kinds; cultivators, fewer to many; villagers, few; and city dwellers, few or none.

The orderly migration of man was facilitated by the possession of domestic animals. At first the movement would be with the grazing herd. At a later stage animals would be used for riding and traction. In war the provisions would be transported on the hoof.

THE NEED FOR A THIRTEENTH MONTH

By M. N. STILES[1]

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THE UNIFORM MONTH OF THE 13 MONTHS PLAN
Every Month 4 Weeks

Sun	Mon	Tue	Wed	Thu	Fri	Sat
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28

IN considering the reform of the calendar, certain things should be kept in mind:

(1) Calendar reform no longer has to be the business of astronomers, who on occasions of previous reforms were the chief authorities consulted. The changes with which they dealt had to do with adjusting the calendar to the length of the solar year. That task was finally accomplished with the Gregorian reform of 1582. The reforms now proposed have nothing to do with astronomical equations for the solar year, but with the composition and arrangement of the calendar's months and weeks within the solar year. It is purely a problem of simple arithmetic respond-

[1] Mr. Stiles was a delegate of the National Committee on Calendar Simplification for the United States to the first International Conference on Calendar Reform at Geneva in 1931.

ing to economic and social considerations arising from the use of the months and weeks.

(2) The demand for improvement has arisen chiefly because of the radical changes in our economic and social life that have occurred during the last one hundred and fifty years. These changes have speeded up our progress and thereby made it necessary to measure and study it in *short periods of time*, particularly our economic progress. In consequence, because the shorter periods available—the months and the weeks—are hodge-podge in their composition and arrangement, the calendar has become a hindrance rather than a help to progress. The months are not only unequal (31, 30, 29 or 28 days) but (excepting February) contain more than a whole number of weeks, and, in addition, incessantly change in their weekday composition. They are not, in any way, comparable units.

Practical economic convenience is the impelling motive of the movement plus social convenience. Any reform that can not achieve the maximum practical economic and social improvements surely is not worth while. To ask the

MONTHS OF THE EQUALIZED QUARTERS PLAN

January
April
July
October

S	M	T	W	T	F	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

February
May
August
November

S	M	T	W	T	F	S
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		

March
June
September
December

S	M	T	W	T	F	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

world to undergo the disturbance of change for a partial reform and minimum benefit is asking too much.

(3) In modern life the month and the week are the most used units of the calendar. In our personal affairs we scarcely give thought to the quarters of the year as a measure of time; we date and calculate by the month and the week. In the affairs of business the use of the month and the week as measures of performance and for comparative reports and statistics is immeasurably greater than that of quarters. Business no longer waits for a quarter of a year to elapse before finding out where it stands. Hence it is far more important that the months be equalized and that each be a multiple of the week than to have a mere equalization of the quarters, as proposed by some. Scientific data based on periods of time is likewise measured far more in months and weeks than quarters.

(4) In choosing a plan of reform, practical experience is the test of worth. More than 400 large businesses in the United States and Canada have within recent years adopted private business calendars consisting of 13 equal "months" of four weeks each. They use these in order to escape the disadvantages of the 31 and 30-day months and broken weeks of the present calendar for their accounting, statistical reports and business management. The business use of the 13 four-week periods in Europe is also growing. Should successful experience with a plan of calendar reform be left out of consideration in comparing it with a plan that has never been tried?

The Two Plans

The 13 months principle of reform, proposed for universal adoption as a fixed perpetual calendar, is designed to meet the compelling economic and social requirements for equal months. A 13th month is introduced because, without abandoning the use of the 7-day week, equal months of four weeks each can be secured in no other way. The alternative proposal for a fixed calendar, which merely equalizes the quarters in order to keep the traditional 12 months, can not correct the inequality in the lengths of the months, can not provide for months containing a whole number of weeks, can not prevent changes in the week-day composition of the months from one month to the next. This is because its months consist of 30 or 31 days and have fractional parts of weeks.

Let the features of difference in the structure of the 13 equal months plan and the 12 unequal months equalized quarters plan be compared:

The 13 months calendar divides the year into months of four weeks each. The names of the present 12 months are retained. The additional month, called "Sol," is placed in the middle of the year, between June and July, in order to disturb as little as possible the positions of the present months within the year. Calendrically, December has 29 days and the last week of that month has eight days. This eighth day is given the non-week-day name of "Year Day," to be dated December 29, and would be observed as a holiday. In leap years the last week of June has eight days with the last day given the name of "Leap Day," dated June 29, and would likewise be observed as a holiday.

Practically a 364 day business year is thus created, for the most of our business activities. Each month then becomes an exact multiple of the week and, as nearly as nature will permit, each month is a sub-multiple of the calendar year, and an exact sub-multiple of the 364 day business year. In terms of months, the quarters do not contain a whole number of months, but each quarter has exactly 13 weeks. Each year would begin on Sunday. Each month

would begin on Sunday. Each quarter would begin on Sunday. Each day of the week in each month would fall perpetually on the same four recurring dates. This arrangement is the nearest possible to a perfectly uniform, perpetual solar calendar that can be devised without abandoning the use of the seven-day week.

In contrast, the 12 months plan is limited to making only the quarters of the year uniform. This is done by shifting seven dates, which alter the lengths of five months in such a way that each quarter will contain one month of 31 days and two of 30 days. The "Year Day" is introduced at the end of the year and "Leap Day" in the middle of the year as in the 13 months plan.

Each year would begin on Sunday and the first month of each quarter would begin on Sunday, but the second month would begin on Wednesday and the third on Friday, so that in each succeeding month throughout the year the week-days would fall on different dates. The quarters are equal, each with 13 weeks, but the inequality among the months is perpetuated. No month is a multiple of the week. The glaring defect of broken weeks at the beginning and end of months is perpetuated. There would be sixteen broken weeks in every year. The 31 and 30-day months are in neither case a sub-multiple of the 364 day business year, nor are they as nearly a sub-multiple of the calendar year as are the months of the 13 months plan.

The Practical Requirements

Notwithstanding the defects of the 12 months plan, its advocates urge that it be chosen by governments for submission to their legislatures on the ground that the 13 months plan would not be accepted by the public. A calendar introducing another month would be "too revolutionary." They place much emphasis, too, on the indivisibility of 13 as an objection to 13 months. They also argue that making the calendar perpetual and limiting the changes to equalizing the quarters will effect all the improvements that are essential.

To those who have given but casual thought to the question of calendar improvement and to those not practically familiar with its bearing on business life, the 12 months equalized quarters compromise has a plausible appeal. Without doubt, too, it appeals to the ultra-conservative mind, to those who approach the question from an academic view-point, to those influenced by the superstitions of numerology and to the ultra-sentimental. But from the standpoint of the practical work-a-day world, it is easy to show that the 13 months plan alone meets the practical requirements; that the alternative proposal demands that the public undergo the disturbance of a change without commensurate benefit, and, if adopted, would leave to posterity the task of another revision.

From the economic standpoint the 13 months plan alone can meet the two following requirements.

(1) Business comparability of any month with the corresponding month of previous years.

(2) Business comparability between different months of the same year.

This is simply because each month has four weeks, composed of the same number of the same kind of business days (barring holidays which are present in any calendar).

The 12 months equalized quarters plan meets only the first. It can not establish comparability between different months of the same year because (a) Four of its months have 31 days and eight have 30 days. (b) Eight of its months have fractions of one week and four have fractions of two weeks. (c) In all of its months two or three days of the week variously occur five

times, such as five Saturdays, five Sundays, etc., causing variations in the total business value of each month.

Advocates of the 12 months plan excuse the lack of comparability between one month and another by saying that such comparisons are not essential. They say that it is of paramount value to compare August, 1933, with August, 1932, for example, but is of little value to compare August, 1933, with July, 1933.

If this claim were valid, if comparisons only between months of different years were of paramount value, very little reflection will show that it would not be necessary to change the calendar at all, except in two slight particulars. We need only to give December 31 of the *present* calendar the name of "Year Day" and February 29 the name of "Leap Day"; in other words, simply make the present calendar a perpetual calendar, and the purpose of securing comparisons between months of different years is fully accomplished.

It must be quite clear that if without other change these two specially named days be introduced into the present calendar, every year can be made to begin on Sunday and the annual shifting of the days of the week to different dates in each month will cease. Each month will then have its exact counterpart in every year as to order, number and kind of days of the week it contains. Therefore, correspondingly named months in the present calendar will be exactly comparable.

What then is the use of the new 30 and 31-day months of the 12 months plan? Why cause the disturbance of rearranging the months when the desired comparisons between the same months of different years can be secured by the far simpler and less disturbing expedient described above?

The obvious fact is that this rearrangement is made to secure the equalization of the quarters and in proposing this and pointing to it as an advantage, the advocates of the 12 months plan concede that, at least to that extent, equalization of periods *within* the year does have value.

But equalization of the quarters is as far as the 12 months plan can go in producing comparable periods *within* the year. The advocates of the 13 equal months plan show that this does not go far enough to be worth the change.

Worth-whileness

First, from the standpoint of comparability within the year, the mere equalization of the quarters of the year meets no compelling economic requirement, because the use of the quarter of the year as a business time unit is exceedingly small compared with the month and because the quarters are already nearly equal in the present calendar.

Second, while accurate comparability between corresponding months of *different* years is an essential requirement of any reform of the calendar, accurate comparability between months of the *same* year is equally essential, if not more so.

The sound reason for these statements is that a vast number of comparisons between months in the same year are now used in our economic life, and that such comparisons would be universally used if the months were equal. In a multitude of businesses profit and loss accounts are compiled by the months and compared not only with the same month a year ago, but with previous months of the same year. Statistical reports such as those of sales and production are similarly compared as a general rule. One need only scan the financial pages of newspapers, the published statistics of trade associations in trade magazines and the business statistics issued each month by the Department of Commerce to find that in most of them comparisons are made with the

previous month as well as between the corresponding month of the previous year. In some cases they are adjusted for calendar-caused distortions, in others given for what they are worth. Innumerable charts and graphs are constantly being prepared to show monthly trends within the year.

An outstanding example of month to month comparisons of vital importance to our economic life is the monthly statistics of foreign trade and the resulting changes in the trade balance, frequently distorted when there are five week-end sailing dates in one month compared with four in the previous month.

Importance of the Week

Furthermore, a multitude of statistics are now based *on the week*. These can not be correlated with the months of the present calendar nor could they be with the months of the 12 months plan. The fact is that in many businesses where *weekly* statistics of sales, production, etc., are essential to keep close track of performance and of current trends, and where *monthly* statistics are also essential for monthly financial statements, the splitting of weeks at the beginning and end of months requires extra labor that would be eliminated if four weeks coincided with a month. This defect of the present calendar is one of the reasons why the use of the 13 months business calendar is growing.

Again excusing the inequality of the months of the 12 months plan the claim is made that they are practically comparable with one another because each has twenty-six working days. This claim is not, from a business standpoint, a valid one, because of the different business values of the days of the week.

For example, March of the 12 months plan has five Saturdays and February only four. The retail trade—chain stores, department stores, grocery stores, etc.—do a large per cent. of their business on Saturday.

March likewise has five Fridays and February four. Evening newspapers get the largest portion of their advertising on Fridays.

March has four Wednesdays and Thursdays, but February has five. Hotels get the best patronage on Wednesdays and Thursdays.

Thus monthly comparisons within the year would continue confusing for a multitude of businesses.

Further, if the five-day working week be adopted the comparability of consecutive months would be even more confusing. Again for those industries which operate *every* day of the week such as transportation, public utilities, moving-picture houses, steel and iron mills, etc., the twenty-six work-day claim has no point whatever.

Again, consider the use of the months within the year for the purposes of budgetary control and compare the simplicity of apportioning expenses to months the same in length and composition with the difficulties of doing the same to months of unequal length and varying composition.

In sum, were the 12 months plan to be adopted, only part of the job would be done. August of this year, for example, would be truly comparable with August of last year, but not with July. This serious defect of the 12 months plan for economic uses can not be disputed and is so because, except for the rare business for which the seven days of the week are all the same, each successive month of that plan has a changed comparative value because of its different week-day composition. Why perpetuate it?

Moreover, it is obvious that unless it is a perpetual calendar (to which there is religious objection from seventh day Sabbath keepers) the 12 months plan practically loses *all* its value. Deprived of "Year Day" and "Leap Day" there would be an incessant change in the week-day composition of all its months

from year to year as well as within the same year, just as in the present calendar, with the result that its year-to-year comparability between months would be lost entirely and thereby nothing left but a mere equalization of the number of days in the quarters, 91, 91, 91 and 92 instead of 90, 91, 92 and 92 as at present. The difference involves a change in seven dates, but what is the use of changing seven dates when the mere equalization of the quarters can be achieved with much less disturbance, *simply by transferring August 31 to February 29?*

On the other hand, the 13 months division without "Year Day" and "Leap Day" still remains worth while because it can achieve a large percentage of the benefits of the reform. There would be four weeks in each month containing the same number of the same kind of days except December with an extra day each year and June with an extra day in leap years. The order of these days in each month would, of course, change each year and the holidays would change to different days of the week (Thanksgiving and Labor Day to different dates) but the months would be comparable just as are the four-week periods of private business calendars.

The Indivisibility of 13 Months

Notwithstanding the indisputable fact that throughout our economic life, the month and the week are by far the most used periods of the calendar, the 13 equal months plan is assailed as impracticable on the ground that "quarterly statements are a fixture in present day business and finance," and that since 13 months are not divisible into quarters, the preparation of such statements would present difficulties.

The answer to this criticism is that if it were true that the business of the country were exclusively accounted for on the quarterly basis, there would be no good business reason for adopting the 13 equal months plan.

Many businesses, it is true, issue quarterly financial statements, but for what purpose? Primarily for the information of their stockholders, their bankers, and the investing public, to show the condition of the company. But no modern business could possibly be successful if its management allowed three months to pass before gaining knowledge of the results of its performance from time to time within that period. This is the reason for comparative monthly reports of sales, production, operating and other costs, and for monthly profit and loss statements that are now so generally in use. The quarterly report is but a recapitulation of these working reports for shorter periods.

But even as recapitulations, are financial statements strictly by quarters of the year essential? Are they so vital to our business life that it is more essential as a method of calendar reform to equalize the quarters than to equalize the more frequently used months? It is significant that some users of the 13 months business calendar, who formerly issued quarterly financial statements, have abandoned them and use only monthly and annual statements. Others find the purpose of quarterly statements —the financial condition of the company —is as well served by making them at the end of 3, 3, 3 and 4 month periods. Incidentally the New York Stock Exchange accepts such statements from companies using the 13-period division.

The Indivisibility of 31 Days

The objection to a year of 13 months as not being divisible into quarters is largely psychological. It comes from the habit of thinking of the calendar as constructed of months without consideration of the fact that the calendar also contains days and weeks which enter into the composition of these months

and of the year. Consciously or unconsciously the equalized quarters advocates fit their arguments into this psychology. When they object that a 13 months year is not divisible by four, they ignore *the fact that 31 and 30-day months are also not divisible by four.* They stress the fact that you can quarter their year and forget the fact that you can not quarter their months.

Now in calendar reform, the fact has to be recognized that it is mathematically impossible to have a calendar in which, while preserving the seven-day week, the year may be quartered into months and the months quartered into weeks. You can not have both together. A choice must be made between them. At the risk of laboring the point, I repeat that the most used divisions of the calendar are the month and the week, from which it follows that the benefits that would be derived from being able to quarter the months into weeks would overwhelmingly exceed those that would come from a slightly more accurate quartering of the years into months.

The difference between any of the 90, 91, 92 and 92-day quarters of the present calendar and the 91-day quarters of the equalized quarters plan is scarcely more than 1 per cent. But 31 and 30-day months can not be quartered into weeks without leaving a remainder of 42 and 28 per cent. of a week respectively.

For the Future or the Past?

The criticism is also made that from the statistical standpoint comparisons of the 28-day months of the 13 months calendar with the months of the past would be of little value without laborious and costly recomputation, and that in many cases it would be impossible to convert records of the past into records with which records under the new calendar could be compared. Particularly during the next few years, it is argued, it is essential that economists and business men have all the aid possible from past business records.

To quote one critic: "A radical change of the calendar [that of 28-day months] would seriously reduce the usefulness of those records and thus hamper the adjustment of business to world needs at a critical time in the advance of civilization." This, it is contended, would not be the case under the 12 months plan, because "comparisons for any month in the new 12 months plan, with those of corresponding months under the present calendar would not be seriously interfered with. Direct comparison of unreduced monthly figures for corresponding months would in many cases be satisfactorily accurate, and after a lapse of a few years, so that comparisons were entirely within the new calendar, they would be entirely accurate."

Before coming to the points of this criticism, let it be said that as an argument against the adoption of the 28-day months of the 13 months calendar, they would have a certain amount of merit were the change to be made without preparation for it, but as an argument for the adoption of the 31 and 30-day months of the 12 months plan, they provoke a smile from the 13 months calendar advocates.

We are here told in effect that the resemblance between the months of the new calendar and the old would be so close that the change would make little difference; accurate comparisons between corresponding months would be gained without a serious break in the continuity of statistics. Very good, but why change *any* of the months and upset dates when as previously pointed out the desired accuracy can be secured simply by leaving the months as they are and inserting "Year Day" and "Leap Day" to make the calendar perpetual. There would thus be even less interference with past comparisons, and all the advantage claimed in this respect

for the 12 months plan would be secured. Why give February 30 days, when its present 28 days will do just as well for year by year comparisons in the future and much better for the past? Clearly, from the standpoint of the criticism in question, the calendrical structure which its authors present for avoiding a supposedly serious break with the past is adorned with superfluous embellishment.

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But let us see if the break in the continuity of statistics which would be caused by the adoption of 28-day months would be as serious as alleged. In the first place, the present depression, and prior to that the war, have shown that long time economic statistics are of no great comparative value. There is a sad humor about this. Too many underlying conditions have changed, too many bases upon which the statistics were built have risen or fallen to different levels to give long ago business records any important practical face value in comparing them with the present, unless accurate allowances can be made. In any case—and this is the point that does not seem to be perceived—*long ago statistics are rarely compared by months, they are compared by years.* Who compares the price index, sales record, manufacturing output or profit and loss account of December, 1932, with the same for December, 1922, or December, 1912, unless it be for curiosity. The view as far back as that is to the *years*, not the months. It does not seem to be realized that the use and importance of monthly comparisons lie almost wholly in their disclosure of the changes and trends *from one year to the next and within the current year.* It is chiefly from these data of the immediate past that business makes its decisions for the immediate future.

Five years is certainly the extreme limit of use for individual monthly comparisons in the business world, and to say that the value of long time statistics, needed only for cycles and trends over a series of years, would be seriously reduced unless recomputed in terms of 28-day months can not be admitted as true.

We have left then to consider only the relatively short period immediately prior to the date for the revised calendar to go into effect. Is it to be supposed that our economic life would make no preparation for the change? Should an international agreement be reached in 1935 to put the 13 months calendar into effect in 1939, is it to be supposed that business would do nothing in the meantime to adjust its statistical data to the new months? Naturally it would do so, and in different cases it would do differently according to the requirements. Undoubtedly in most cases the change would be anticipated by adopting the 13-period division of the year for statistical purposes as soon as possible, as has already been done by hundreds of businesses in this country and abroad. In some cases undoubtedly two sets of records would be kept, one on the present calendar and one on the new, for one, two or three years prior to 1939. (In the age of bookkeeping machines this is not so laborious as may be supposed.) In others it would be found more desirable to "start from scratch" as did many businesses now using the 13-period division, when they made the change and put up with the temporary inadequacy of their comparisons for the sake of permanent advantage.

Thus it is seen that the break in the continuity of statistics would by no means have the serious effect upon their utility that is imagined.

And when calendar reform is tied up with present economic conditions as indeed it is by those who advocate early adoption of the 13 months plan as a means of closer scrutiny of business costs and the direction of trends, it is easy to

see that the short time monthly comparisons have by far their most important value as between and within the years of the immediate future, rather than between those years and the years either of the immediate or distant past. This service for the future, as has been shown, the 12 months plan is only partly able to perform and solely by reason of the fact that it is a perpetual calendar.

The Real Question

In sum, reduced to its practical aspect, the 12 months advocates in arguing that their plan will make little difference, not only confess a lack of accomplishment, but more naïvely than this, they demand for their plan alterations in the length of five of the months that *do* cause some difference and then say that since the difference will not be as serious as under the 13 months plan, let us make these lesser changes, notwithstanding that for the purpose of comparing corresponding months they are unnecessary.

The only *valid* reason for disturbing five months is to equalize the already nearly equal quarters; but that can be done by disturbing only two months, and when it is done in either way what benefit do we get? Only the small benefit that can come from the correction of a slight irregularity.

Clearly no alterations in the months are worth while unless they are thereby made equal. The *real question*, therefore, is the expense and inconvenience involved in the adjustment. To attempt to estimate this would be futile, but the fact that several hundred businesses have already made the change can not be ignored. Nor can the fact be ignored that hundreds of others are on record as saying they are ready to make the change at once, if business in general will do likewise. If the cost were thought to be great, naturally the change would not be considered worth while.

Social Convenience

From the standpoint of the everyday use of the 12 months plan for dating events and calculating days and weeks between dates, its perpetual feature does indeed fix week-days to perpetual dates as between corresponding months from year to year; but within the year, *for which the calendar is mostly used*, the improvement over the present calendar is slight. From month to month the week-days change to different dates requiring efforts of memory and calculation little less than at present. Printed calendars would still have to be consulted except by the few with good enough memories to remember the recurring differences among three kinds of months. And without the perpetual feature the 12 months plan would be no improvement whatever as a dating and time-calculating instrument.

In contrast, the 13 equal months plan fixes week-days to the same dates not only as between the same months from year to year but also within the year. Memorizing the dates of one month would suffice for all and the calculation of weeks and days between dates would be simple. And without the perpetual feature, it would still be a considerable improvement over the present calendar; because in any *current* year the week-days would fall on the same dates of each month and there would be no fractions of weeks to confuse the calculations.

Clearly, if we are to stop in calendar reform with the mere equalization of the quarters, the job will have to be done over again some time in the future. Why take two bites at a cherry?

HEALTH COSTS AND THE BUSINESS CYCLE

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THE high cost of medical care has long been a matter of deep concern. Especially is this true since the mass of people have been educated to what might well be termed "health consciousness." The great strides of preventive and curative medicine have paralleled this "health consciousness," and to-day medical care is deemed as essential for one class as it is for another. Provision for medical care is a matter which faces every family, and assumes most serious proportions for the majority of families belonging to the great middle class. It is the purpose of this article to inquire into the movement of medical costs, to determine whether medical costs tend to increase or to decrease during a period when the prices of commodities, wages and salaries in general are subjected to severe deflation, as has occurred during the past few years and, conversely, what is the trend of medical costs in times of a rising general price level, and particularly in an era of active inflation.

PHYSICIANS' FEES

As a rule, specific economic goods and services tend to rise or fall in price in accord with the general price level, assuming that there have been no significant changes in the demand for and the supply of such services or goods. There are, however, certain types of goods and services whose prices are not readily responsive to general economic price movements. In this category are those goods or services which command specific prices fixed by law or by some legal body vested with such power. Rates charged by railroads, telephone companies and other public utilities are of this sort. These are—often belatedly, it is true—usually adjusted by the rate-making body in course of time to the prevailing general price level. Likewise in this category of relatively inflexible prices are those that pertain to certain goods or services for which a customary price is paid. Customary prices are not fixed by government or other deliberate authority; they are the result of long-continued custom and are modified only with great difficulty. Under this classification the fees of the general medical practitioner must be placed.

The prevalent general practitioners' fees in urban communities throughout the United States are $3 per home call and $2 per office visit. These fees have been customary in such communities for years, certainly for more than a decade. If it is assumed that the customary fees were well adjusted so as to afford the average client with medical service at such a price as he could afford, and were adequate enough to provide the average physician with a modest standard of living, it is at once apparent that the maintenance of the same rates to-day represents a price for the same grade of service far in advance of that charged from, say, 1920 to 1929. Since the latter date the price levels of commodities, wages and salaries have declined considerably, as we all know. A family doctor bill of $100 for the year 1928 represented 5 per cent. of a given workman's yearly income of $2,000. To-day, if the workman is fortunate enough to have his job, it is not unlikely that his yearly income is in the neighborhood of $1,500, which would represent a typical 25 per cent. reduction. On the present income basis a family doctor bill of $100, representing exactly the same amount of service as for the year 1928, is equivalent to 6⅔ per cent. of his reduced income.

Measured in terms of wholesale prices for commodities, the medical dollar of the present purchases the same amount of care as it did in 1926, but if employed in the purchase of commodities the purchasing power of the dollar of 1926 is equivalent to $1.639 as of January, 1933, and $1.538 as of June, 1933. As an indication of the actual decline in the spending power of wage-earners, it might be added that in January, 1933, earnings in manufacturing industries were only 35.8 per cent. of the 1926 level, while employment was only 56.6 per cent. of the 1926 level.[1] As of June, 1933, the figures were 43.1 and 62.8 per cent., respectively.[2] However, it was commonly felt in 1926 that medical costs were at that time so high as to be beyond the means of the average workman. If any truth is to be accorded to this assumption, it must be conceded that physicians' fees, remaining nominally the same as five years ago, have in reality reached a level much higher and further beyond the reach of the average working man than was the case five years ago.

What has been said with reference to the fees of the general practitioner applies with even greater force to the much higher fees of the specialist. There is this difference, however. Specialists' fees have never been nearly so uniform as fees for ordinary medical service; they have been adjusted up and down at all times to fit the ability of different clients or of different classes of clients to pay, and in time of depression it is much easier to scale such flexible rates down to any level desired by the specialist. Since such rates are, to a large extent, personal, readjustments may be made at any time without setting a precedent. On the other hand, the customary nominal rates of the general practitioner can not be juggled so readily. A downward revision, say from $3 to $2 for home calls and from $2 to $1 for office calls, would tend to establish a new customary price for such services in the community. There would be no public opposition to a downward revision; in fact, it would be received with public commendation. But once this lower customary rate had been established, it would be doubly hard to institute an increase in rates when the general price level advanced. Any upward revision of a customary price is bound to elicit an undue amount of public antagonism, and cause the beneficiaries to be classified by the populace as racketeers or profiteers, to say the least.

The fact that the family doctor bill for an equivalent amount of service represents a much larger proportion of the average man's income to-day than it did a few years ago may seem to lead to the conclusion that the medical profession is profiting enormously as a result of customary fees. But such is not the case. There is no professional group from which the public seems to expect so much as the general practitioner. In hard times he is expected to be very lenient in the collection of his bills, and naturally he can not be otherwise when his clients are drawn from the poorer and the middle classes, and are suffering from greatly reduced income, either from wage reductions or unemployment, or both. Under such circumstances the average physician finds himself treating many patients who have no means whatsoever, and little likelihood of early employment. In this group many will prove outright charity patients, others will resolve to pay when they have the means, and of these some are prone to forget their obligation as it grows older. The ratio of bad debts has shown a phenomenal increase, especially during the past two or three years. In many urban sections the increase in the proportion of bad debts over that existing prior to the depression amounts to from 200 to 250

[1] *Monthly Labor Review*, March, 1933, Vol. 36, No. 3, pp. 659, 699.

[2] *Ibid.*, August, 1933, Vol. 37, No. 2, p. 411.

per cent. Many doctors have employed an instalment system of collecting their bills, although this method has not proved particularly successful at a time when unemployment is so wide-spread.

We thus see that even with the maintenance of a nominal fee and performance of the same amount of service as in better years, the increase in charity work and in uncollectible bills so reduces the average physician's nominal income that, in spite of the increase in purchasing power of the dollar, his total purchasing power is considerably curtailed. Moreover, there is little likelihood that the average doctor can maintain the normal amount of practise and the same ratio of home visits to office calls to which he was accustomed before the depression period. This is because of the necessity on the part of the majority of people at such a time to curb all unusual expenses, in which class they are wont to place medical expenses. Hence there is increasing reluctance to call a doctor to the home except in cases of extreme illness, and where possible office calls are substituted for home calls. Furthermore, a growing proportion of the public has sought to reduce medical costs by attendance at pay clinics, while others, utterly unable to pay for any medical service, have resorted to free dispensaries and clinics.

The reduction in the number of patients has had the effect of increasing competition within the ranks of medical men, and this in turn has resulted in some places in practises which under ordinary circumstances would be regarded as unethical. Thus there has grown up a certain amount of price cutting, especially by younger doctors who have not yet secured a foothold in their profession and are faced with economic insecurity to a disconcerting degree. Formerly price cutting, where it existed, was done on the sly, whereas to-day it is done quite openly, such doctors advertising the fact that their services are available at clinic rates. Certain clearly unethical practises, which in the parlance of the day might well be called "rackets," have made an appearance or have become more pronounced under the exigency of hard times. In this category might be placed the keen competition for insurance examinations with the hope of inducing the prospective policy-holder to undergo medical treatment not absolutely necessary. Quite often the patient is directed to a cooperating "specialist," who later shares his fees with the doctor from whom the patient was originally sent. He in turn may also play the rôle of "specialist" and receive patients from other doctors under similar arrangements. Compensation cases arising from industrial accidents have in many instances been subject to abuse by requiring the worker to report long after his injury has healed. This is because a certain sum is allowed for each visit of the injured, and stretching the work out as long as possible means added fees.

Dentists' Fees

The situation with reference to dentists' fees is a counterpart of that relating to physicians' fees. However, advertising and price cutting entered this field at an earlier date than in the case of medicine, and has furnished more direct and open competition than has yet appeared in the general medical field. Advertising has become so common in many communities that the old attitude of skepticism and distrust of such dentists has largely given way. This has resulted in a closer relationship between dental fees and the general price level in such communities than exists elsewhere where efforts to maintain customary rates have been successful.

Hospital Costs

To pursue further our inquiry as to the relation between medical costs and industrial depression, let us next glance

at hospital costs. Here again appears the customary price. In the vast majority of hospitals certain fixed rates for the various classes of service are determined upon, usually in accord with the published rates of other institutions prevailing at the time. Once established, these rates tend to become customary; if established during a period of high prices, they are apt to be in conformity to a relatively high price level, and if adopted in a period of low prices the opposite tendency appears. Thus it is not unusual to find noticeable discrepancies in rates nominally asked for a given grade of hospital service by different institutions. Inasmuch as a phenomenal growth of hospital facilities occurred during the decade just passed, it is not surprising that hospital rates for the newer, remodeled or rebuilt institutions tend to reflect the relatively high price levels then prevailing. Moreover, during the period of prosperity the public demand was increasingly in the direction of more exclusive, and therefore more expensive, hospital accommodations, which naturally resulted in attempts to supply such a demand. Furthermore, the growing competition of proprietary hospitals in urban communities no doubt encouraged many private non-profit-making hospitals to add to their more expensive accommodations.

In general, the nominal hospital rates which prevailed in 1928 remain practically unchanged. As in the case of physicians' fees, hospital costs for a given grade and amount of service take a much larger proportion of a man's income to-day than they did in 1928. To those of the great middle class particularly, who have employment and some savings left, hospital costs have relatively increased when consideration is given to lower wages, salaries and to a lower commodity price level.

For a great proportion of the people still above the charity or relief level the effects of the current depression have been so devastating that when hospitalization is needed, cheaper accommodations are now sought. As a consequence the demand for ward, semi-ward and semi-private room service has increased, while the competition of proprietary hospitals for the patronage of those who can still afford to pay for higher priced services, particularly private rooms, remains unabated. This situation has resulted in overtaxing the more moderate priced services, and in many instances in substituting higher priced accommodations which are no longer in great demand for the cheaper accommodations and at the lower price. This is, of course, equivalent to a reduction in price for the better accommodations for those who are the beneficiaries of such a substitution.

The extent of unemployment has increased by a wide margin the number of those who, in need of hospitalization, are unable to pay anything for the service. In metropolitan centers where municipal hospitals are available the demands upon this type of institution have increased greatly, frequently taxing such hospitals beyond their capacity. Likewise the private hospitals which accept charity patients have experienced a cumulative increase in the number of such cases. A sizable proportion of the charity patients of the present time is drawn from the self-supporting working classes, who, during normal times, would revolt at the mere thought of free or even subsidized medical and hospital care.

One of the outstanding consequences of the current depression is the growing conviction that existing or new hospitals should endeavor to provide hospital services for patients of moderate means at such a cost as they can bear.[3] In New York as well as other cities many hospitals are deliberately breaking down

[3] For a full account of this movement see Niles Carpenter, "Hospital Service for Patients of Moderate Means," Publication No. 4, Committee on the Costs of Medical Care.

the former customary rates for hospital service and substituting therefor a flexible scale of rates. Thus charges are based on ability to pay. The incoming patient or his immediate relatives are interviewed by a member of the social service staff of the hospital who thereby obtains sufficient data on the patient's economic status to recommend a fair charge for the individual case under consideration. This practise is applied not only to ward patients, but to those necessitating private or semi-private accommodations. If this custom is more extensively developed, and that seems to be the trend, many of our urban hospitals will have solved the problem of providing facilities for the great middle class, most of whose members, so abhorring the thought of hospitalization in the ward, desire private or semi-private facilities, but do not have the means to pay for such. A practise of this sort would automatically cure some of the evils resulting from customary prices in times of high or low general price levels.

Clinic Fees

With reference to clinic fees little can be said for the simple reason that such charges are generally so small as to represent no great burden upon the average patient either in periods of high or low price levels. Furthermore, it is a common custom in many part-pay or free clinics, where a small fee is asked, to dispense with such payments in needy cases. Pay clinics, on the other hand, which charge the full cost of the service rendered plus a profit for the doctors participating are scarcely more apt to reflect economic changes than customary doctors' fees. It is conceivable, however, that pay clinics representing the cooperative efforts of physicians in providing medical services to their patients at less cost to the physicians may likewise be employed to reduce the cost to patients, and some attempt made to correlate clinic rates or fees to the prevailing level of prices.

Nursing Costs

Nursing is another field in which there has been a tendency toward customary or inflexible rates. This is seen especially with respect to the trained or "private duty" nurse. Efforts to maintain "prosperity wages" for this group under existing conditions have resulted in much unemployment. To quote from the final report of the Committee on the Costs of Medical Care: "The private duty nurse practising individually occupies a position of increasing economic insecurity. So rapid has been the growth in the number of nurses that there are far more private duty and institutional nurses than can be employed under present circumstances. Yet the needs of the people, if fully supplied, would call for all the nurses. The situation is an excellent illustration of the distinction between need and demand. The barrier is primarily, although not exclusively, an economic one."

Other Medical Costs

Many other medical costs illustrate the same inflexible price tendencies which we have already noted. For instance, the price of prescriptions remains about the same year in and year out, showing little apparent relation to manufacturing or wholesale costs of drugs entering therein. It would seem that when the general price level is low the pharmacist values his services more highly, and when the general price level is higher he regards his personal service as of lesser value. It might be said that what the pharmacist loses in purchasing power through selling prescriptions at a stable price, relatively low in times of prosperity, is made up by that same stable price, relatively high in times of depression. Nevertheless, this practise presents just one more instance of a medical cost remaining out of line with respect to general prices, thereby making it more difficult for the consumer to purchase necessary medical attention in times of falling prices. Moreover, the pharmacist in-

variably sells for cash, whereas doctors, nurses and hospitals never collect the full nominal sum for their services because of bad debts and charity work.

The retail prices of "patent" medicines and nostrums, on the other hand, are more apt to reflect general price changes than are prescriptions. This is especially true since the advent of the chain drug store, the department store and the mail order house. Widely advertised proprietary medicines afford an excellent drawing card when deeply cut prices are advertised, and this, no doubt, encourages a certain amount of self-medication, a practise which is scarcely to be approved. In this field alone, then, do certain medical costs seem to follow the general trend of prices.

Conclusions

In no field of modern business nor in any of the professions is there to be found the relative fixity of charges which persists in medical and allied health work. In industry wages, salaries and commodities are extremely sensitive to fluctuations in the supply of or demand for labor or goods. Prices of individual commodities or services, barring unusual changes in the particular supply or demand, tend to conform to the rise or fall of the general price level. A striking exception, however, is found in the various branches of medical and health work. Here customary fees or charges, once adopted, show tremendous resistance to change. This phenomenon has a decided influence upon the ability of the poorer, and even the middle economic groups of our population, to purchase necessary medical attention. In periods of depression medical care becomes relatively more expensive, although remaining absolutely the same in dollars and cents. The consequences are deferment of medical care if the individual's health is not in a precarious state, resort to cheaper health agencies, such as office calls at the physician's office instead of home calls, a shift in demand from more expensive and exclusive hospital accommodations to those of a less costly grade, and greater use of part-pay and free clinics. Frequently the patient of limited means seeks quick and cheap relief by the use of patent medicines or other nostrums, and also at the hands of quack doctors who do not hesitate to advertise their low rates and cure-all methods, while in more prosperous times little thought would have been given to these questionable agencies.

No gains are experienced by the medical profession, hospitals or other legitimate health agencies through the strict maintenance of customary fees or charges. Considerable practise is lost to the ordinary practitioner, price-cutting tends to make its appearance here and there, and fee-splitting and other unethical practises become more or less general. Much work is performed by the general practitioner for which immediate or early payment is impossible. Customary fees in a time of depression cause the doctor's bill to appear overwhelming and unreasonable, and as a consequence many of such bills become uncollectible since the outraged debtors refuse to make any efforts at payment. Moreover, the amount of free work is greatly increased. Hospitals, as well as other health agencies, find themselves in a similar plight.

Medical and health agencies and individuals engaged in such work are powerless to overcome the wide fluctuations of the business cycle. The causes are, of course, industrial in nature, and the more important adjustments must be made in that field through stabilization of the price level, banking reform, industrial planning and the like. But within the medical field an abandonment of customary fees and charges would seem to be an apt adjustment. The consuming public, especially the self-supporting working class groups, would be enabled to purchase medical care at a

cost within reach, and physicians, nurses, hospitals and other agencies would receive more in a period of depression by charging lower nominal rates for services than they would through the maintenance of customary fees because of the very fact that at such a time they simply can not obtain the income the customary rates seem to demand.

On the other hand, physicians, nurses, hospitals and clinics would benefit greatly without the incubus of customary price in a period of prosperity. Then medical costs could be raised in keeping with the rise in the general price level. As a consequence the public would be in a position to expend a relatively stable proportion of its income for medicine, both curative and preventive. As a means of maintaining a certain degree of uniformity in physicians' fees within an area, local medical societies could easily publish approved standard rates from time to time, say every three to six months, which would thereby keep medical costs in alignment with the prevailing general price level. A similar plan might also be worked out with reference to dentists' fees, and even the rates for nursing service might be made amenable to such a scheme. This suggested program would naturally require a certain amount of publicity, and assurance that adjustments in rates, especially increases, were not arbitrary for the purpose of fleecing the public, but were made in accord with a well-known price index as a means of making physicians', dentists' and other medical fees reasonable at all times. As for hospitals, a similar arrangement would seem quite feasible, assuming a desire to maintain a rate schedule for the various grades of service offered. The end in view, however, is already being accomplished to some extent by the application of flexible rates in many institutions.

It has recently been pointed out that socialized medicine by means of group practise and group payment will bring the cost of medical care down within the reach of the vast majority of people. There is no certainty that this will result, for, in fact, if customary group fees, even though paid in a fixed sum monthly, quarterly or annually, become the rule, the same difficulties are bound to ensue as are now found in competitive medicine. Moreover, should medicine be so completely socialized as to become a state function physicians would find themselves on a fixed salary basis, probably with little or no distinction between the good or the bad, the competent and the incompetent, and would be subject to all the vicissitudes of changing price levels without the slightest means of adjustment. This difficulty would be felt most in times of prosperity accompanied by a rising price level. From the standpoint of the public, in the case of state medicine, the costs would be disguised in the form of taxes, and the entire burden would be shifted to certain groups of taxpayers, although many of the beneficiaries, not possessing taxable property or resources, and yet able to bear ordinary medical expenses, would be exempt from all costs.

SCIENCE SERVICE RADIO TALKS

PRESENTED OVER THE COLUMBIA BROADCASTING SYSTEM

THE POPULATION PROSPECT

By Dr. O. E. BAKER

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I SHOULD like, if I may, to consider with you the effect of the change, particularly noticeable since the world war, in the desires and ideals of the young people—their decisions as to what is worth while—upon the prospect for population growth in the United States. We are approaching the time when children will be born, with few exceptions, to those parents only who want them. What does this mean in terms of national development and destiny?

For twelve years the number of births in the United States has been less each year than in the year preceding, with three exceptions. In 1933 nearly 700,000 fewer children were born than in 1921. In addition, the flow of immigrants from Europe has been stopped; indeed, each year during the last three years more people have left the United States than have entered it. Ten to twelve years ago the yearly increase of population in the nation was about 2,000,000. Now it is less than 1,000,000. In 1933 it was, apparently, a little less than 800,000. The enrolment in the lower grades of the schools has started downward and will soon decline rapidly.

Moreover, there is no sign that the decline in the birth rate is slowing up. And already there are not enough children being born to maintain the present population permanently. However, the population of the nation will continue to increase for at least five years, probably fifteen years, possibly twenty years, principally because of the large number of middle-aged people, the heritage of a higher birth rate and heavier immigration in the past. As these middle-aged people grow old and die the death rate will rise, not because people are dying younger, but because there will be more and more old people to die. The census of 1930 showed that people over 65 years of age had increased 34 per cent. since 1920 in the nation as a whole and 50 per cent. in the cities. The census of 1940 will show a similar increase of old people, and by 1950 there will be nearly twice as many old people in the nation as in 1930.

Slowly the number of deaths will increase, while the number of births seems likely to decrease for some time to come. Probably 10 to 20 years hence births and deaths will balance. This balance may last for a few years, resulting in a stationary population. Afterward deaths will exceed births, unless the birth rate rises or the restrictions on immigration are relaxed. When this occurs the population of the nation will begin to decline. According to estimates of Thompson and Whelpton, of the Scripps Foundation for Research in Population Problems, at Miami University, Ohio, the population of the United States in 1940 will be about 132,000,000. By 1950 the population will have increased to 136,000,000. In 1960 the population will be about the same as in 1950, the peak having been reached between these years. By 1970, according to this estimate (which is only one of several these statisticians offer,

but the one I prefer) the population of the nation will have declined to about 132,000,000, and by 1980 to 126,000,000, which is about the same population as at present.

This estimate was made more than a year ago. The continued rapid decrease in births in 1933—more than 100,000 fewer, apparently, than in 1932—suggest that the stationary population may be nearer than even this "low" estimate of Thompson and Whelpton indicated. If the increase in the nation's population continues to diminish at the same rate as during the last ten years, the population of the nation will be stationary about 1942.

We have probably 15 years ahead of us before the peak of population is reached, and 30 years before the decline from this peak will have reached the present population level. There is time in which to develop a new attitude toward children and family responsibilities, and change our manner of living so that children will not cost so much to raise and educate as at present. Dr. Dublin, statistician of the Metropolitan Life Insurance Company, estimated prior to the depression that the average cost of raising a child to the age of 18 in New York City was about $7,500, or fully $10,000, if 5 per cent. interest on the investment be allowed. Three children per mother, the number necessary to maintain population stationary, mean, therefore, an investment of $22,000 to $30,000. The average cost on the farms is probably only a third as large, and in the small towns and villages is intermediate. The decline in the birth rate would, doubtless, be retarded if a larger proportion of the people lived in suburbs, small cities and villages, particularly if many engaged in part-time farming.

According to the census of 1930, the number of children under 5 years of age in the large cities lacked about 20 per cent. of being sufficient to maintain a stationary population permanently, without migration from rural areas or immigration from foreign lands, while in the smaller cities there was about 6 per cent. deficit. On the other hand, in the village and suburban population there was a surplus of children of fully 30 per cent. and in the farm population a surplus of 50 per cent. above the number necessary to maintain that population stationary. In 1930 urban deficit and rural surplus about balanced, according to Dr. Lotka, of the Metropolitan Life Insurance Company, but since 1930 the national birth rate has declined 12 per cent. further. The rural population is no longer able to maintain its own numbers and provide enough young people for the cities, even if jobs could be found for them, to balance the urban deficit. The large cities particularly may well consider the handwriting on the wall. We may be on the verge of great shifts in the residence of the people.

Fully as important, I believe, as an increase in the proportion of the population living in a rural environment is an increase in the number of parents who are willing to sacrifice for the sake of children and the preservation of the family line. In my opinion, the accelerated decline in the birth rate which followed the world war was owing not only to the high cost of living, particularly in the cities, but also to the disillusionment of many young people after the war and to changes in their desires and ideals. The craving for luxury, amusements and social position apparently became keener than before, and the striving for a higher standard of living became more wide-spread. In many, perhaps in most, cases this higher standard of living could be achieved only by a rigid restriction on the size of the family; as a hard-working, married student in a university, who had two chil-

dren, remarked to me several years ago: "No more babies until we have an automobile."

This rapid decline in the birth rate is as wide as the European sphere of civilization. A stationary population in Great Britain, France, Germany and the Scandinavian countries will be reached, it is now estimated, within ten years, and a few years later decline will set in. It appears that our modern urban economic system, with its associated social ideals, tends to reduce the birth rate below the level of population maintenance as universally as the former self-sufficing agricultural system tended to maintain it above that level. In every state of the United States, without exception, the ratio of children under 5 years old to women of child-bearing age is smaller in the urban population than in the rural; and this is true also of every nation of Europe that collects birth statistics, likewise of Canada, Australia, New Zealand and Japan. The social code, if such it may be called, which is characteristic of the people in the cities particularly, is unquestionably promoting depopulation. And it seems unlikely that this code will be changed in time to prevent a declining population in the United States and the nations of northwestern Europe.

After the decline sets in there may develop a movement of religious intensity directed toward the preservation of the family, the nation and the race. To be a parent of healthy children may afford as much social prestige as to be the owner of a high-priced automobile or of over-stuffed furniture. It is possible that this change in ideals and in estimates of things worth while may develop before the decline in population actually sets in. Let us hope so, for a declining population will have very serious economic, psychological and biological consequences.

THE HYGIENE OF HAY-FEVER

By Dr. HARRY S. BERNTON

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"DEATH, taxation and hay-fever are inescapable." This is the cry of resignation of 2 per cent. of our population. Hay-fever was first described as a disease entity by physicians of the old English school. The view that hay-fever is caused by the pollens of flowering plants has now met with universal acceptance. However, the disease is one of greater concern to the American public. Approximately 70 per cent. of hay-fever victims in this country owe their distress to the pollens of the ragweeds. Curiously enough, the geographical distribution of the ragweeds is restricted to the North American continent. The blooming period of these weeds extends from the middle of August until the advent of frost. This period embraces the fall or autumnal variety of hay-fever, in contradistinction to the spring and summer types of the disease. The spring type is due to the pollens of the trees, whereas the summer type is caused by the pollens of the grasses or of the plantains.

Two months hence, the vast army of sufferers will begin to experience their "annual torment," to use the phrase of an English physician, and sneezes will resound throughout the length and breadth of our land. Recurring popular appeals to exterminate the ragweeds accompany the symptoms of distress. Ob-

viously, the attempt to annihilate any species of plant or animal life is attended with unsurmountable obstacles. It constitutes primarily a defiance of the laws of creation.

Of all the diseases to which human flesh is heir, hay-fever enjoys an unusual distinction. It is regarded as the most serious of non-fatal maladies. Its symptoms have been made the subject of jest. "Hay-fever" is even the title of a comedy-drama. Fits of sneezing, a copious discharge from the nose and eyes, stuffiness of nose, intolerable itching of the lining membranes of the nose, eyes, mouth, throat and ear canals, and occasional attacks of asthma furnish evidence of the irritating qualities of the pollen grains upon the tissues of susceptible persons. These local manifestations are only too well recognized by the members of the family circle to which the victim belongs. In this instance, at least, familiarity breeds sympathy. Nevertheless, one of the most apparent complications of hay-fever is a defective heat-regulating mechanism. This condition was tersely described by a patient when he bewailed the fact that his thermostat was out of order. The disturbance of the heat-regulating mechanism of the body is an integral part of the disease which has failed to receive the attention it merits. The authoritative works, which have enriched our literature of the past decade, fail to emphasize this important constitutional derangement. It occurs during, and in some cases extends beyond the seasonal upheaval. Now, there is a school of economists which attributes the present economic ills to the mechanized age. The coincidence is, indeed, a strange one, that this mechanized age has also conspired to provoke and aggravate the distress of hay-fever patients.

The maintenance of the body temperature and the conservation of body heat are two of the most vital functions of the human body. Their successful accomplishment depends upon a delicately coordinated mechanism—such as the nerve fibers in the skin and in the walls of blood vessels which convey impulses to and from the spinal cord. These impulses are in turn conveyed from the spinal cord to the heat-regulating center in the brain which acts as the thermostat, so to speak. Under normal conditions, body temperature is maintained at a fairly constant level because heat production and heat loss are equal, and because any change in either process brings about a compensating change in the other.

The term "hay-fever" is a paradox. It is a non-febrile disease. Nevertheless, hay-fever victims do feel hot and feverish. The skin is usually warm because of the dilatation of the blood vessels therein. More blood is brought to the surface from which heat is dissipated. This condition is not unlike that seen in alcoholic intoxication and explains the blush and the flush of inebriety. The dilatation of the blood vessels results from a disturbance or poisoning of the nerve fibers which control the caliber of blood vessels. Pollen disease with resulting poisoning from the absorption of the soluble pollen material is a more accurate designation than hay-fever.

When cold air strikes the skin, there is an immediate loss of heat. The warmer body radiates its heat to the colder environment. One of nature's inexorable laws is the conservation of body heat. This is effected by the contraction or shutting down of the blood vessels in the skin—a mechanism which is quite analogous to shutting off the heat from a radiator by closing the valve. A diminished volume of blood now courses through the skin, whereas the excess of blood finds its way in part into the mucous membrane of the nose. Herein are

located the so-called turbinate tissues or "swell bodies," which act very much like the ordinary sponge. Their volume varies with the volume of contained fluid. The engorgement of the turbinate bodies causes the familiar sniffing, and the consequent pressure upon the nerve endings in the nasal mucous membrane gives rise to sneezing. This is a common experience. The congestion of the "swell bodies," irrespective of cause, is indicated by sneezing, fulness of the nose and nasal discharge. These reactions of the nasal tissues are more marked in the case of hay-fever subjects due to impairment of nerve functions. Therefore, the effects and symptoms are more lasting than in the normal person.

Let us now consider the innovations which tend to bring about a dissipation of body heat. The automobile ranks first in importance to the hay-fever patient. When horse-power furnished the sole means of transportation twelve to twenty miles per day of travel was a reasonable expectation. That same distance can now be covered by motor car in one-half hour or less. With windshield up and windows down the automobilist is transported through space at a faster rate than ever before in the history of man. The faster the rate of travel, the faster does body heat radiate to the quick onrush of air. The passengers, attired in light summer garb, are denied the protection of adequate clothing against such a rapid loss. At journey's end, the hay-fever victim finds that disease and discomfort have displaced relative ease and comfort. Moreover, a ride in the rumble-seat is anything but a joy-ride. The wet eyes and the wet nose tell their own story.

In the new design for automobiles, the no-draft ventilation seemingly atones for the all-draft ventilation of the rumble seat. "Do not travel during the hay-fever season" is a slogan worthy of adoption by all victims of the disease. It is difficult to explain the reasons which prompt the hay-fever subject to plan automobile tours during the season of his greatest disability. If a tour of the country is to form part of a recreational program, it should be arranged for those months when the hay-fever victim is free from symptoms. Then and only then will a vacation prove symptomless.

Engorgement of the nasal tissues, with the train of symptoms previously described, likewise results when the air is agitated around and about the individual in a quiescent state. The electric fan, another contribution of the mechanistic age, may similarly produce the dire effects in rotation. It is particularly noteworthy that the rate of air-speed in the case of the more powerful electric fans varies from 6.8 to 19.3 miles per hour. The reports of hay-fever subjects who are unwillingly and unwittingly exposed to the direct currents of air of electric fans indicate that their symptoms are either provoked or intensified. The reasons are only too obvious. Under normal conditions a person who anticipates exposure to gusts of air, with a velocity of nineteen miles per hour, will protect himself with a light outer garment. In the office and shop, during the season when fans are in active operation, a minimal amount of clothing consistent with modesty affords no barrier to the rapid loss of body heat.

Some thoughtless persons engage in a practise which is especially fraught with danger. They permit an electric fan to blow directly upon them while asleep. It will be recalled that hay-fever patients, because of their unstable heat-regulating mechanism, tend to lose body heat. Moreover, during sleep, even in the normal individual, the temperature falls because of bodily inactivity. The vessels of the skin are usually dilated,

owing to the diminished control exercised by the dormant nerve centers. When, in addition, the electric fan incites a still greater dissipation of body heat, the awakening is indeed sad. In the early morning hours the hay-fever subject is likely to be aroused out of his sleep by vigorous blasts of his own creation. Mothers and nurses will do well to heed this warning. The direct exposure of sleeping babies and children to the currents of air of electric fans is an act which can not be condoned by any humane consideration.

The movie industry has, also, moved many a hay-fever victim to tears and sniffles. This industry has pioneered in making indoor amusements attractive to the populace during the hot weather season. To accomplish this purpose, the artificial cooling of theaters has become an important adjunct. The patron of the arts, warm of body and with undergarments saturated with perspiration, enters the air-cooled auditorium. Eventually he is seated in the huge refrigerator. He is in cold-storage for at least two hours. His reaction to the new environment is determined by the difference between the indoor and outdoor temperatures. A difference of ten to twelve degrees may serve to add comfort to the enjoyment of the show. However, the differences are usually greater. The subjection of the human body, especially when thinly clad, to such a sudden fall of external temperature causes a rapid dissipation of body heat. The normal individual readily accommodates himself to the changed conditions. His heat-regulating mechanism functions adequately. The hay-fever patient soon experiences the stuffiness of nose and paroxysms of sneezing. The inevitable result of an evening intended for pleasure is the intensification of symptoms for twenty-four hours or even longer.

The extension of the use of air-cooling devices on trains and in office buildings is fraught with similar peril for the hay-fever victim. To compensate in part for the loss of body heat, it follows that one should bestir himself into some form of muscular activity. This obviously is impossible in the air-cooled train or theater. The hay-fever subject restrains every motion excepting the commotion of pent-up sneezes.

Dress, dictated by fashion, has now approached the vanishing point. "Back to Nature" may be fitting for members of the Nudist cult, but it is distinctly unsafe for young hay-fever victims. The physiological purpose of clothing is to conserve body heat. Young children, attired in the conventional sun-suit, expose a vast expanse of body surface to the fluctuations of the external temperature. In case of children who are hay-fever or asthmatic victims, the loss of body heat is attended by a flare-up of their distress.

The American people displays its national temperament in its policy of keeping cool in the hour of trial. The hay-fever victim, however, should, in the interest of comfort, harken to the dictate of hygiene: "Keep warm inside and outside."

THE MYSTERY OF THE OCEAN

By Dr. PAUL S. GALTSOFF
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SINCE the earliest days of our civilization the great blue expanse of the ocean has had a mysterious appeal to our imagination. To the inquiring mind of a man of the ancient days the circular disk of his small inhabitable world

seemed to be surrounded by a mighty stream of water which, he believed, was the abode of many fearsome monsters, strange human-like creatures and freaks. This conception, originated by the Chaldeans and Egyptians, was handed down from generation to generation. It was generally accepted in the time of Homer by Greek geographers who called the ever-running river the Oceanus, the name of a primeval god.

The beginning of the science of oceanography dates back to the year 1522, when one of the vessels of Ferdinand Magellan returned to Spain after having for a first time circumnavigated the globe. In 1768 Captain J. Cook, sailing in the *Endeavor*, started on the scientific expedition during which he made the first deep-sea soundings, observed the temperature of the water and collected numerous astronomical and biological data. From this time onward hundreds of expeditions organized by every civilized country have explored the ocean.

Most ingenious instruments and implements were invented for catching various organisms of the sea, ranging in size from the smallest microbe of less than one thousandth of an inch to the largest living mammals, like the blue whale, which reaches the immense length of 85 feet or more and weighs over 300 tons. Fantastic tales about the life in the ocean were gradually replaced by accurate knowledge. Sea monsters and other creatures collected by the expeditions were meticulously examined by scientists and were described and classified. They were carefully preserved in alcohol and placed on shelves and in cases in our great museums.

It is true that with the advance of scientific knowledge the romance and adventure of the old days associated with the great oceanic expeditions have been lost, yet life in the ocean still remains veiled in mystery, and the biologist of to-day, starting on a new exploration, may be as much thrilled as were the pioneers of science who sailed with Magellan and Cook. His principal aims, however, are different. He is more interested at present in determining the laws that control life in the ocean and in unraveling the intricate relationships which exist between the denizens of the sea and their environment, rather than in finding and describing new forms of life.

Perhaps the greatest secret of the ocean lies in its very essence, the sea water. The layman may be amazed to learn that such a common thing as sea water may still be an object of scientific research. Yet our present knowledge of the composition of the sea water is very incomplete. Earlier analyses established that sea water contains about 3½ per cent. of salts, of which over three fourths consist of common cooking salt or sodium chloride, the remainder being made up of small quantities of Epsom salt, gypsum, calcium and others.

Modern analyses reveal its much greater complexity. Out of 80 known elements at least 32 enter into a composition of sea water. Many of them occur in such small quantities that their presence can be revealed only by the spectrographic analysis, and in some cases must be assumed because they are found in the bodies of marine animals and plants. For a long time there was a tendency on the part of the chemist to disregard the importance of substances which are found in the sea water in minute amounts, but recent discoveries in the physiology of nutrition taught us to pay more respect to them. We know, for instance, that iron, copper, manganese and iodine are necessary for the normal functioning of our bodies. Undoubtedly they are indispensable for the reproduction and growth of many marine forms, yet they occur in the sea water in concentrations of only a fraction of a part per million.

Traces of silver and gold were also found in the sea water. It has been estimated that there exist dissolved in the sea 13,300 million tons of silver, or 46,700 times as much as had been mined all over the world between the discovery of America and 1902. The presence of gold floating in the sea and ready to be taken by any one who can do it attracted a great deal of attention. According to the old analyses, each ton of water contained 5 milligrams or one twelfth of a grain of gold. Soon after the war, when Germany found herself desperately in need of gold, the German chemist Fritz Haber attempted to extract it. He found, however, that the actual gold content in sea water was only one one-thousandth of what was previously estimated. Since the cost of extraction would be greater than the value of the recovered metal, the hope of amassing great fortunes out of sea water quickly died out. Although gold recovery failed, the extraction of bromine, an element very valuable to industry, the recovery of which was regarded for a long time as a fantastic dream, is now being developed on a commercial scale, and a first plant is being erected near Wilmington, N. C.

While attempts of the chemists and engineers have been balked by many technical difficulties the problem of extracting various elements from sea water has been successfully solved by the marine organisms. Chemical analyses reveal the interesting fact that certain elements, which are found in the sea only as traces, as, for instance, iron, copper, zinc, iodine, vanadium, barium and boron, are accumulated and stored in the bodies of fishes, mollusks, shrimp and other animals and plants.

The accumulation of iodine is probably of greatest interest and importance. Although it is found in the sea in a concentration of about three tenths of a part per billion, large quantities of it are accumulated by algae, mollusks, crustaceans and sponges. Among the edible fish and shellfish the highest iodine content was found in lobster, which contains 11.6 parts per million, and in our oyster, which contains 6 parts per million. It is generally accepted that the deficiency of iodine in our food is the cause of goiter and that the disease can be prevented by including in our diet food that is rich in this element. In certain algae and sponges the iodine accumulates in such large quantities that it can be extracted for industrial purposes. A very common red sponge, *Microciona,* which abounds on oyster beds, contains more than 5 per cent. of iodine (dry basis).

Many other elements are extracted from sea water and stored in the bodies of living organisms. Calcium, magnesium and phosphorus are used by fishes, mollusks, coelenterates and others for the construction of bones, shells and skeletons. Many sponges use silica for building up a network of thin needles which support their bodies. Unicellular Radiolaria select strontium, of which they construct their beautiful skeletons. Sac-like sedentary ascidia accumulate vanadium and use it in the same manner as iron is used in the blood of warm-blooded animals. There are many instances, however, when the purpose of accumulation of the material and the use made of it by the organism are unknown. Thus, we are unable at present to explain why oysters and clams store about 10,000 times as much zinc and more than 1,000 times as much copper as is present in sea water. We do not know why lobsters and sponges need iodine, which they accumulate in their bodies.

In the light of modern science the ocean appears to us as a huge chemical laboratory in which the work goes on continuously without interruption; and the chemical activities of its inhabitants seem to be as diversified as their appear-

ance and structure. Different elements are withdrawn from water, temporarily stored in the bodies of living forms and after their death are deposited on the bottom and redissolved. It has been estimated, for instance, that due to the activity of living forms about 1,400 million tons of lime are being deposited annually on the bottom of the sea. A study of the chemistry of the ocean shows that the turnover of various elements is intimately related to the organic life in the sea and that the life cycles of various forms constitute only brief links in these chemical changes.

To many marine organisms the sea water is not only a medium in which they live but is the essential constituent of their bodies. Suffice to mention the forms, like the jellyfish, which contain more than 90 per cent. of water. Many organisms, like the sponges and coelenterates, are continuously forcing a stream of water to go through their bodies, providing themselves in this manner with food and oxygen for respiration. In these forms sea water plays a rôle of blood in higher animals.

Biologists have accumulated sufficient evidence to maintain that life began in the ocean and that fresh-water and land animals developed from marine forms. In this connection it is interesting to mention that the blood of higher forms, including man, contains the same mineral salts that are found in the sea. It is probably fortunate that scientific research in solving the old mysteries of nature has opened up new fields of investigation and encountered new secrets. Maybe the day will come when the key to the solution of the greatest mystery, the origin of our life, will be found in the depths of the ocean.

THE LIZARD-EATING SPIDERS OF BENGAL

By GOPAL CHANDRA BHATTACHARYA

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THAT some spiders feed on vertebrates is no longer contestable. Accounts of different vertebrates, such as fish, rats, snakes, frogs, lizards, etc., being captured by different species of spiders in different parts of the world have been recorded. Dr. Ernest Warren[1] describes his observations on certain lizard-eating spiders, *Palystes natalius*, as follows:

> At the beginning of July, 1923, Mr. W. G. Rump, caretaker of the Natal Museum, has noticed on a sunny morning at about 10 A. M. in a garden in Pietermaritzburg two large spiders on the woodwork of a fence, at a height of about 4 feet above the ground. The two spiders, with a leg span when walking of about 3 inches, were seen close together clinging to some large dark object. One spider was killed, while the other escaped, and the object to which both spiders had been attached proved to be the body of a recently killed lizard, *Lygodactylus capensis* (A. Smith) which, when straightened out, was about 2¾ inches in length. . . . Subsequent experiences render it probable that the lizard had been killed by the spider or spiders, less than an hour previously.

A series of interesting accounts of fish and lizard-eating spiders has been collected by Dr. Gudger[2] and contributed to the *Natural History Magazine*, New York. From a private communication from him I understand that he has some more material on the subject in hand. Captain Thomas Hutton[3] refers to Galeodes (vorax?) as the lizard-eating spider of Mirzapore, Bhowalpur and Afghanistan. He says "A lizard three inches long, exclusive of tail, was entirely devoured; the *spider* sprung at it, and made a seizure immediately behind the shoulder, never quitting its hold until the whole was consumed." But Galeodes are not considered to be real spiders. They represent something between scorpions and spiders.

No instance of true lizard-eating spiders from India and especially from Bengal has so far been recorded. Recently, however, while experimenting with spiders for finding out the location of their auditory organs and determining if parthenogenesis really takes place in them, I have come across a species of these lizard-eating spiders, *viz.*, *Argiope pulchella* Thor., of the family of Argiopidae found in Bengal. These Argiopidae were found suitable for the above experiments, and I reared a number of young Argiope in several small rooms. Some of these spiders were provided with frameworks of wood, specially made for the purpose of constructing their webs, while others were allowed to make their snares anywhere at random. After closing the glass windows, live specimens of dragon-flies, moths, butterflies, etc., were from time to time let loose in these experimental rooms, in one of which a spider of the size of about 3 inches from foot to foot built a web measuring no less than 3 feet square. On May 8, 1933, I saw a medium-sized dragon-fly (*Crocothemis servilia* Drury) caught in a corner of the web. The fly, having stuck in the glutinous thread of the web, flapped its wings vigorously to set itself free, at which the spider, which was resting quietly on the X-shaped flossy ribbon at the center of the web, got frightened and ran off to one

[1] Ernest Warren, D.Sc., "Notes on a Lizard-Eating S. African Spider," *Annals Natal Museum*, Vol. 5, Part I, p. 95, 1923.

[2] E. W. Gudger, "Spiders as Fishermen and Hunters," *Nat. Hist. Mag.*, Vol. xxv, No. 3, pp. 266–275, May–June, 1925.

[3] Captain Thomas Hutton on Galeodes (vorax?), *Jour. Asiatic Soc.*, Bengal, Vol. xi, Part II, p. 860. July–Dec., 1842.

extreme corner. After half an hour or so I was surprised to see a moderately big lizard sticking to the web near the fly and struggling to get out of it. A wide rent had been made in the web, evidently by the struggling lizard, which by then was dangling with its head and feet stuck in the glutinous thread of the web, the broken threads in their turn having entwined the hinder part of its body. The flapping of the wings of the fly must have attracted the lizard to the death trap. As soon as I drew near, the latter made a violent effort to set itself free but all in vain, so effectively was it snared that only the opening of the rent grew wider. I retired to a suitable distance and awaited further developments. After a few minutes' struggle the lizard became exhausted and motionless. All the while the spider was seen clinging to the ceiling of the room and was, as it were, quite indifferent to the disturbances that were

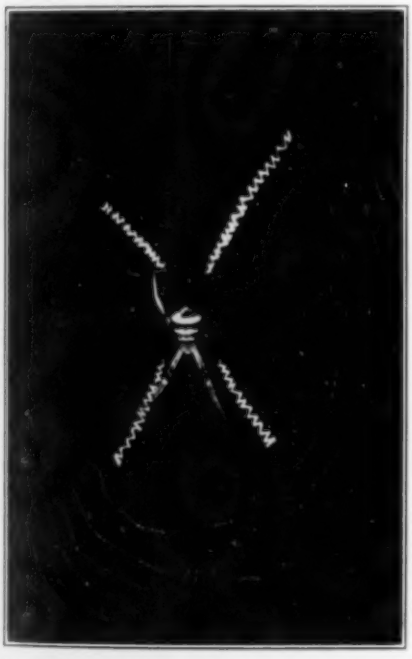


FIG. 1. THE SPIDER IS SITTING AT THE CENTRAL CROSS OF THE WEB

FIG. 2. THE LIZARD IS SEEN STUCK IN THE WEB AND THE SPIDER AT THE CENTER

going on in its web. Fifteen to twenty minutes elapsed in suspense, when the lizard made another violent effort to free itself from the snare. Instantly the spider came down and tore off a radial line so that a large portion of the web was loosely thrown over the struggling victim. The spider silently watched for a minute or two and then suddenly springing upon the lizard swathed it by a stream of flossy ribbonlike threads with the help of its hindmost legs. The body of the victim being larger and heavier than that of its own, the spider could not revolve the lizard bodily for a perfect swathing, but only threw streams of flossy silk over the captive. At this moment the lizard, thus entangled, made a final and desperate attempt to free itself. This time at least fortune smiled on the poor creature, and it escaped carrying along with its tail a portion of the web. The perplexed spider, being denied the dainty meal, retired to the

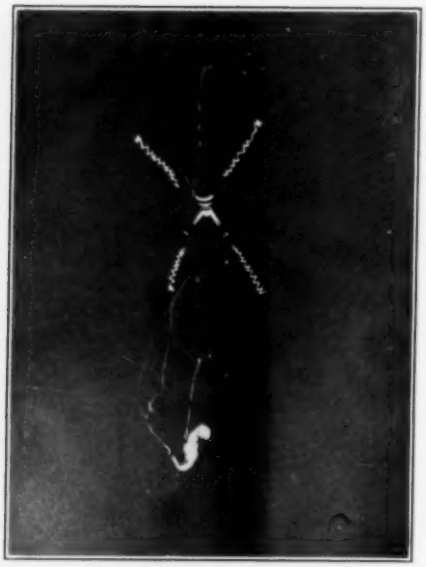


FIG. 3. THE TRUSSED-UP LIZARD IS SEEN ATTACHED TO THE WEB

central cross and began to toilet its head and feet.

Being encouraged by this incident, I placed the same spider on a wooden frame in order that it might construct a fresh web therein. By the evening the spider had actually built up a large beautiful web inside the frame and was quietly sitting at the central cross (Fig. 1). The frame with the spider was then removed to a lumber room full of common house lizards, *Hemidactylus coctaei*. A simple device was made by means of a wooden elbow-bend to entice the lizards to the web. One arm of this elbow-bend was attached to the ceiling of the room, the free end of the other arm being placed very close to the vertical plane of the spider's web. On the other side of the web, just opposite the free end of the arm, was placed a stand, on the top of which a living dragon-fly was mounted. The gap between the fly and the free end was hardly more than an inch, the web occupying the intervening space. The idea was that the flapping of the wings of the fly would attract the lizards and cause them to climb down the elbow-bend and spring upon the fly. Though the device was complete I had to wait a couple of days before anything actually came to pass. I replaced a fresh and vigorous fly every day, as I had noticed one or two lizards going back from the elbow-bend, owing to the weak fly having stopped moving its wings. Then on May 26, 1933, at about 3 P. M. in the afternoon I noticed a lizard actually stuck in the web in its attempt to capture the dragon-fly. The lizard measured about $3\frac{3}{4}$ inches in length from head to tail. Under the weight of its body a big rent was made in the web, in which the lizard itself got entangled and was hanging loosely. It made a vigorous attempt to set itself free from the snare, but in vain. After a few minutes' struggle it remained motionless for a considerable time, when a photograph was taken (Fig. 2), the spider in the meantime having returned to its original position. Half an hour passed quietly, when the lizard began to strug-

FIG. 4. THE SPIDER IS SUCKING THE JUICE OF A CRUMPLED BIT OF FLESH OF THE LIZARD

gle again. All the time the spider was getting ready to attack the victim, and no sooner did the lizard begin to move than it sprang upon the latter and began to throw flossy streams of ribbon all over its body. The struggling of the lizard continued, but the spider did not stop throwing flossy silk until it was completely mummified. The spider then firmly attached the trussed-up victim to the web and took a drag-line to the central cross where it fixed the other end of the line. It then displayed a peculiar dancing attitude by raising its body upon its legs for three or four times, which is the usual practise with all the spiders of this species, in order, as it were, to express its joy and excitement at the success just attained.

The spider kept quiet for some time and then mended a portion of the upper part of the torn web and partially rebuilt the cross at the center. The lizard was still alive, the shivering of its body being distinctly visible through the translucent silken threads. Fig. 3 shows the trussed-up lizard and the position of the spider on the web. At about 6 P. M. that very evening the spider crawled to the trussed-up victim and inserted its fangs into the neck of the lizard. Inside the silken sheath, the lizard, which was still alive, shivered twice or thrice and was silent forever. The spider remained biting for a few minutes and afterwards dragged the swathed victim to the center of the web, where it began chewing the latter to pulp. Next morning by 11 A. M. only a crumpled bit of flesh and skin was left and it could by no means be recognized as the remains of the lizard (Fig. 4). The photograph shows the spider busy chewing the crumpled bit. By a quarter past twelve the spider stopped eating and dropped the remnants to the floor. On examining the crumpled black mass a portion of a lacerated skin and smashed head, with traces of broken pieces of bones, could be recognized. The spider, with its abdomen now greatly distended after the repast, remained sluggish for the next five or six days, during which time it refrained from taking any more food. It did not even care to mend the web or make a new one. A few days later, however, the same spider captured another young lizard in a freshly constructed web and devoured it in the same manner as detailed above.

The observation just recorded is not a stray or accidental one. I have, under similar circumstances, observed exactly similar behavior on the part of other specimens of the same spider.

D. MENDELÉEFF

THE PROGRESS OF SCIENCE

THE CENTENARY OF A SCIENTIFIC PROPHET—DMITRI MENDELÉEFF

ALL over the world, wherever lectures in chemistry are given, and nowadays in most physics lecture rooms there is found a table or chart listing and classifying the elements. This table usually bears the name of Mendeléeff, who was its inspired originator. Many readers may recall that this "Periodic System of the Elements" is prominently displayed at the Chicago Century of Progress Exposition.

In September of this year Russia celebrates with a series of scientific gatherings in Leningrad and Moscow the centenary of the birth of one of its greatest men of science, Dmitri Ivanovitsch Mendeléeff.

Mendeléeff was born in Siberia of good intellectual and pioneer stock. The last and seventeenth child, he was dedicated by his mother to the pursuit of higher learning. Dogged by family misfortunes, illnesses and poverty, he was only just able to gain admittance to a college in St. Petersburg which provided him with all material necessities and brought him into contact with a number of recognized scholars. Years later he was permitted by the Minister of Public Instruction to study abroad in Paris and in Heidelberg. Shortly after his return he became professor of chemistry at the Technological Institute, and in 1869, at the age of thirty-two, professor at the University of St. Petersburg.

In March, 1869, Mendeléeff presented to the Russian Chemical Society his immortal paper, "On the Relation of the Properties to the Atomic Weights of the Elements." This was a remarkable generalization which covered all the 63 elements known at that time. Mendeléeff himself points out forerunners who had compared small groups of similar elements, but adds, "they merely wanted the boldness necessary to place the whole question at such a height that its reflection on the facts could be clearly seen."

All the elements were now arranged for the first time in the order of their atomic weights, whereupon they were seen to be periodic in that they fell into successive lines of a table in which similar elements came in the same vertical column. There were gaps and discrepancies, but closer study justified Mendeléeff's classification.

As regards the gaps, Mendeléeff had the courage to predict that new or *eka*-elements would be discovered with properties which he described in remarkable detail. There are diamatic moments in the intellectual progress of mankind, when the force of controlled imagination leads to the discovery of a reality in nature. Thus the calculations of Adams and Leverrier had predicted the existence and position of an unknown planetary body, which was then found by Galle in its prescribed place and called the planet Neptune. Similarly, in 1875 Lecoq de Boisbaudran discovered a new element gallium with all the properties of *eka*-aluminium. In 1879 Nilson described scandium and in 1886 Winkler, germanium. These were *eka*-boron and *eka*-silicon.

Even Madame Curie's polonium, named for yet another country, and not discovered until the twentieth century, was Mendeléeff's *dvi*-tellurium. Another name for it is radium F. This brings out something that Mendeléeff did not foresee, the series of radioactive elements and another group due largely to Ramsay, the so-called rare or inert gases which now form our street signs. Now the system of 92 elements is complete

D. MENDELÉEFF—JANUARY 27, 1834–JANUARY 20, 1907

with the heaviest element uranium of atomic number 92. The atomic number, which runs closely parallel to the atomic weights, has proven in recent years to be more fundamental even than atomic weights, for now, for most elements, it has been found that there exists a group of isotopes almost identical, save in atomic weight. The impetus to all this later work was given by Mendeléeff, and its constant guide has been his classification. The key to a partial explanation has since been given by our later discoveries of the constitution of the atom. Much remains to be done before we have a complete system of the structure of the nuclei.

Jeans has suggested that since our observations are confined to the surface of the earth and the outer atmospheres of the stars and since the earth itself is only a sample of the outer atmosphere of the sun, our 92 elements may constitute only a small fraction of the weight of the universe. In this connection it is interesting that within the last few weeks there is reported the deliberate creation by Fermi of Naples of a new element of atomic number 93 by adding one unit to uranium. We recognize ever more clearly the prophetic insight which may be attained or vouchsafed into fundamental realities of nature.

Mendeléeff introduces his work on

Periods		Group 0	Group I	Group II	Group III	Group IV	Group V	Group VI	Group VII	Group VIII
Type of Oxide Type of Hydride		—	R_2O RH	RO RH_2	R_2O_3 RH_3	RO_2 RH_4	R_2O_5 RH_3	$R_2O_5(RO_3)$ RH_2	R_2O_7 RH	RO_4 —
			A B H 1 1.0078	A B	A B	A B	A B	A B	A B	
First short period		He 2 4.002	Li 3 6.94	Be 4 9.02	B 5 10.82	C 6 12.00	N 7 14.008	O 8 16.00	F 9 19.0	
Second short period		Ne 10 20.183	Na 11 22.997	Mg 12 24.32	Al 13 26.97	Si 14 28.06	P 15 31.02	S 16 32.06	Cl 17 35.46	
First long period	Even Series	A 18 39.94	K 19 39.1	Ca 20 40.07	Sc 21 45.1	Ti 22 47.9	V 23 50.96	Cr 24 52.01	Mn 25 54.93	Fe 26 Co 27 Ni 28 55.84 58.94 58.69
	Odd Series		Cu 29 63.57	Zn 30 65.38	Ga 31 69.72	Ge 32 72.6	As 33 74.93	Se 34 79.2	Br 35 79.92	
Second long period	Even Series	Kr 36 82.9	Rb 37 85.44	Sr 38 87.63	Y 39 88.92	Zr 40 91.22	Cb 41 93.1	Mo 42 96.0	Ma 43 ?	Ru 44 Rh 45 Pd 46 101.7 102.91 106.7
	Odd Series		Ag 47 107.88	Cd 48 112.41	In 49 114.8	Sn 50 118.7	Sb 51 121.77	Te 52 127.5	I 53 126.93	
Third long period	Even Series	Xe 54 130.2	Cs 55 132.81	Ba 56 137.36	La 57 138.9	Ce 58 140.13				
	Odd Series			The Rare Earth Elements. Atomic Numbers 59-71						
Fourth long period	Even Series					Hf 72 178.6	Ta 73 181.5	W 74 184.0	Re 75 188.7	Os 76 Ir 77 Pt 78 190.8 193.1 195.23
	Odd Series		Au 79 197.2	Hg 80 200.61	Tl 81 204.39	Pb 82 207.22	Bi 83 209.0	Po 84	—85	
Fifth period		Ra 86 222	—87	Ra 88 225.97	Ac 89	Th 90 232.12	UX_2 91	U 92 238.14		

PERIODIC CLASSIFICATION OF THE ELEMENTS—MENDELÉEFF (MODIFIED)

THE NUMBER AT THE RIGHT OF THE SYMBOL IS THE ATOMIC NUMBER OF THE ELEMENT, AND THE NUMBER BELOW IS THE ATOMIC WEIGHT.

"Solutions" in the following interesting lines:

This investigation is dedicated to the memory of a mother by her youngest offspring. Conducting a factory, she could educate him only by her own work. She instructed by example, corrected with love, and in order to devote him to science she left Siberia with him, spending thus her last resources and strength.

When dying, she said, "Refrain from illusions, insist on work, and not on words. Patiently search divine and scientific truth." She understood how often dialectical methods deceive, how much there is still to be learned, and how, with the aid of science without violence, with love but firmness, all superstition, untruth, and error are removed, bringing in their stead the safety of discovered truth, freedom for further development, general welfare, and inward happiness. Dmitri Mendeléeff regards as sacred a mother's dying words. October, 1887.

The centenary of Mendeléeff's birth has recently been commemorated by the London Chemical Society with an address by Lord Rutherford. A much more elaborate celebration is arranged to take place in Leningrad and Moscow over a period of five days, beginning on September 10. Invitations have been issued to a number of foreign guests, and reports will be read relating the great progress recently made by the very numerous scientific institutes in support of which the U. S. S. R. spent in 1933 no less a sum than $320,000,000.

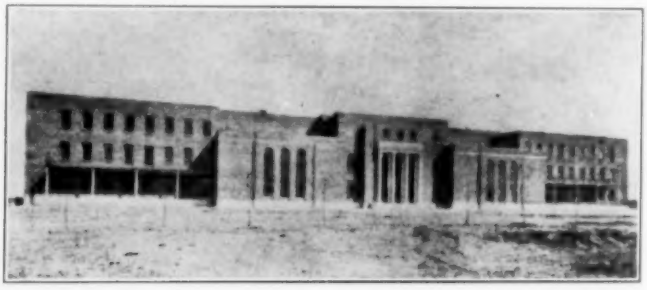
The Soviet postal authorities have issued a series of new postage stamps of five and twenty kopek denominations, bearing a design of the Mendeléeff monument against a background of his table of the periodic system of elements; the ten and fifteen kopek denominations bear a portrait of Mendeléeff, also against a background of the table of the periodic system of elements. All bear the commemoration date 1834–1934.

J. W. McBain

THE INTERNATIONAL CHEMISTRY MEETINGS AT MADRID

EARLY in April Spain was hostess to two international congresses in the field of chemistry, bringing together some 1,200 chemists from all over the world. Before the world war it had become the custom to hold an International Congress of Pure and Applied Chemistry every three years in a different country. In 1909 the seventh congress was held in Rome; and in 1912 the eighth congress was held in Washington, D. C., and New York. The latter was an auspicious event, bringing many of the notables of Europe to America. The ninth congress was scheduled for Russia in 1915, but the world war interfered and there was no resumption of these international gatherings until the recent one.

In the afternoon Dr. Gilbert N. Lewis, professor of chemistry and dean of the college of chemistry at the University of California, lectured on "Different Kinds of Water" in the auditorium of the University of Madrid. Distinguished chemists from many lands presented lectures on as many different phases of theoretical and applied chemistry. There were 34 general and special lectures, but in all some 300 papers were presented. The importance of organic chemistry was clearly brought out, for several times as many papers were devoted to organic chemistry as to inorganic chemistry. A further analysis shows that 57 papers were presented in organic chemistry, 55 in biochemistry,

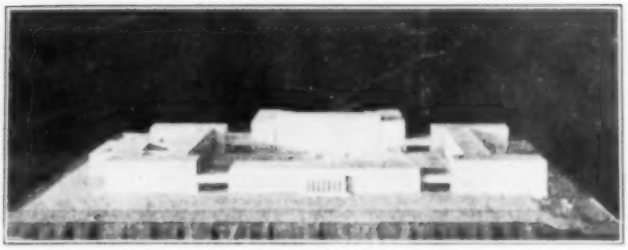


THE NATIONAL INSTITUTE OF PHYSICS AND CHEMISTRY

At the opening session of the congress in the Capital Theater at Madrid General Secretary Professor Enrique Moles gave the address of welcome. The president of the congress, Professor Obdulio Fernandez, gave an address on the advance of chemistry since the previous congress. This was followed with a short talk by Professor E. Biilmann, president of the International Union of Chemistry. This impressive session was brought to a close by President Zamora, of the Spanish Republic, who was seated with the officers on the stage during the morning. The keen insight of this ruler into scientific developments and their significance was a revelation. His genial character and cordiality made one feel at home at once in Madrid.

44 in analytical chemistry and 16 in agricultural chemistry, while only 26 of the papers were classified as pure and applied *inorganic* chemistry.

The American representatives, recommended to the State Department by the National Research Council and the National Academy of Sciences and sent as official delegates, were: Dr. Arnold K. Balls, U. S. Bureau of Chemistry; Dr. Edward Bartow, State University of Iowa, chairman; Dr. J. van N. Dorr, New York; Dr. Raleigh Gilchrist, U. S. Bureau of Standards; Dr. Lauder W. Jones, Princeton University; Dr. Gilbert N. Lewis, University of California; Dr. Atherton Seidell, National Institute of Health; Dr. Alexander Silverman, University of Pittsburgh; Dr. Robert E.



THE NEW FACULTY OF SCIENCES

A PLASTIC MODEL SHOWING THE INSTITUTE OF CHEMISTRY IN THE BACKGROUND.

THE STATE OF CONSTRUCTION

OF THE INSTITUTE OF CHEMISTRY OF THE FACULTY OF SCIENCES SHORTLY BEFORE THE CONGRESS CONVENED.

THE INSTITUTE OF CHEMISTRY OF THE FACULTY OF SCIENCES

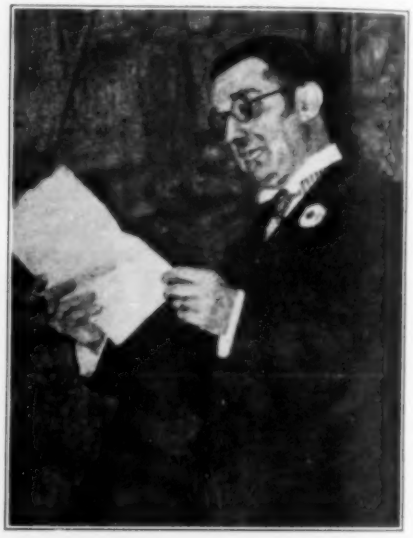
PROFESSOR E. BIILMANN
RETIRING PRESIDENT OF THE INTERNATIONAL UNION OF CHEMISTRY.

Swain, Leland Stanford University; Dr. John W. Turrentine, U. S. Bureau of Chemistry.

On the second day there was a most impressive ceremony in the great hall of the university, where honorary doctor of science degrees were conferred upon Professors Nicola Parravano of Rome,

PROFESSOR NICOLA PARRAVANO
NEWLY ELECTED PRESIDENT OF THE INTERNATIONAL UNION OF CHEMISTRY AND RECIPIENT OF AN HONORARY DOCTOR OF SCIENCE DEGREE.

Henry Armstrong of London, Henri le Chatelier of Paris, Paul Walden of Rostock and Gilbert N. Lewis of Berkeley. Doctor of pharmacy degrees were conferred upon Professors Robert Robinson of Oxford, Paul Karrer of Zurich and Ernest Fourneau of Paris. The colorful ceremonials accompanying these events in European universities added to the dignity and impressiveness of such occasions. It might be noted that two of the men honored were octogenarians,



PROFESSOR ENRIQUE MOLES
GENERAL SECRETARY OF THE NINTH INTERNATIONAL CONGRESS OF PURE AND APPLIED CHEMISTRY, WHO GAVE THE ADDRESS OF WELCOME.

namely, Professor Armstrong and Professor le Chatelier, each of whom is 84 years of age, the first the dean of British chemists, the second, the dean of French chemists. Following the ceremony there was the customary serving of refreshments, wine and champagne, cakes and sandwiches. This seems to be an indispensable part of such events in Spain.

At a meeting of the Spanish Academy of Sciences, Professors G. Garger of Edinburgh, E. Bartow of the State University of Iowa, G. B. Bonino of Bologna, G. Bertrand of the Pasteur

Institute, F. Fichter of Basle, S. P. Sorensen of Copenhagen, E. Späth of Vienna and E. Votocek of Prague were elected fellows of the academy. We should bear in mind that America has been doubly honored in the conferring of the doctor of science degree upon Professor Gilbert N. Lewis by the University of Madrid and the election of Dr. Edward Bartow as a fellow of the Spanish Academy of Sciences.

The closing session of the Ninth Congress of Chemistry and Eleventh Conference of the International Union were held in the great hall of the university. Professor Nicola Parravano of Rome was elected to succeed Professor E. Biilmann of Copenhagen as president of the International Union. It was voted that the next meeting of the Union should be held in Switzerland in 1936. On this occasion expressions of appreciation to Spain for her wonderful hospitality followed in resolution upon resolution. There is no doubt that the government and the business men of Spain must have spent hundreds of thousands of pesetas for the elaborate entertainment of their guests and for the publication of reprints, maps, guide books and exquisitely illustrated volumes on chemistry in Spain and on centers of especial interest. These will ever remain precious souvenirs to those who were fortunate enough to attend the Ninth International Congress of Pure and Applied Chemistry.

Too much can not be said of the extraordinary development in chemical science in Madrid and undoubtedly in other centers in Spain as well. The National Institute of Physics and Chemistry, located in the university, which was founded in 1513 and which now has a student enrolment of over 12,000, already occupies a building provided with well-equipped laboratories, and there is under construction a new laboratory, magnificent in design and gigantic in plan and scope. It will cover at least the equivalent of four American city blocks. The educational system in vogue is worthy of comment. Except for special lectures, the lecture system has largely been abandoned. Students are given every possible facility in libraries and laboratories and resort to conferences and independent investigations for their advancement. Under the sound guidance of their professors they are developing a self-reliance and an ambition for search and investigation which will unquestionably place Spain in the front ranks in the development of chemical science.

The meeting of the International Congress of Chemistry and of the Union in Madrid will ever be a memorable one in the minds of those who were fortunate enough to enjoy the wonderful hospitality of Spain. Much of the credit is due to the efforts of President Obdulio Fernandez and Secretary Enrique Moles of the congress.

ALEXANDER SILVERMAN

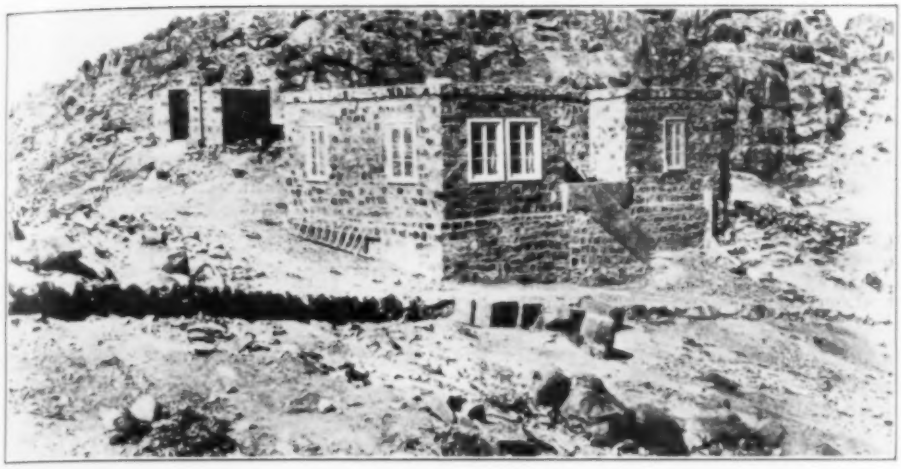
THE MOUNT ST. KATHERINE SOLAR OBSERVATORY

AN American astronomer and his family recently started housekeeping on the summit of Mount St. Katherine in the Sinai Peninsula.

Their cozy granite-block dwelling house, erected for them by the monks of Saint Katherine's Monastery, who are their nearest neighbors, may stand close to the very spot where, in the opinion of some Biblical scholars, Moses received the ten commandments, according to the description in the book of Exodus.

A short distance away on the very peak stands the new observatory, also erected by the monks, where Harlan H. Zodtner, of the Smithsonian Institution, will make daily observations of the radiation output of the sun. Dr. Charles G.

MOUNT SAINT KATHERINE SOLAR OBSERVATORY

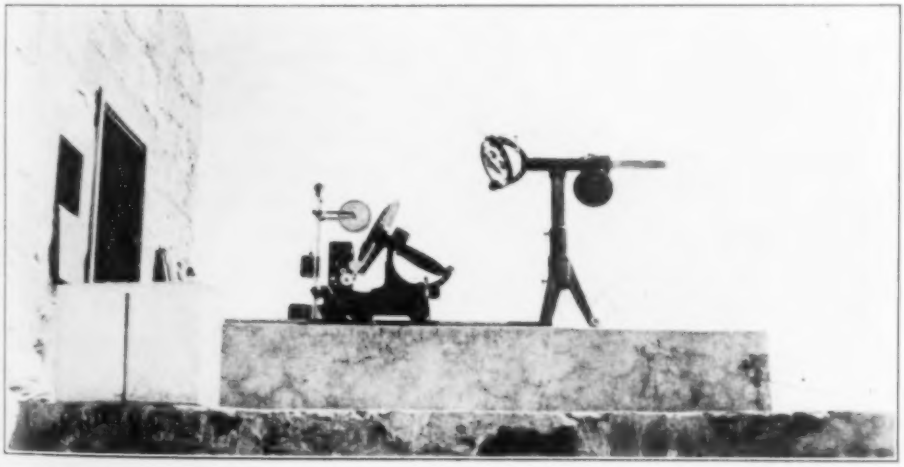


THE DWELLING HOUSE AND SHOP

Abbot, secretary of the Smithsonian Institution, has the signed contract between Zodtner and His Beatitude Porphyrios the Third, archbishop of Mount Sinai, acting on behalf of the convent of Mount Sinai. Under this agreement the dwelling and observatory were erected by the monks and will become the property of the monastery when the institution is through with them. The monks also constructed a road to the observatory and a masonry enclosure around the mountain spring.

The monastery itself, 10 miles away in the valley of Wady el-Der, is one of the oldest in Christendom, and the monks themselves had their nativity in many lands. They have been extremely friendly to their new neighbors. Primitive Christianity and modern science in one of its most advanced branches have entered into a cordial partnership in this strange land, over whose desolation is the glamor of supernatural tradition.

Aside from the monks, Mr. Zodtner, his family and his assistant, Mr. F. A.



COELOSTAT FOR REFLECTING SOLAR RAYS INTO THE OBSERVATORY

MOUNT SAINT KATHERINE SOLAR OBSERVATORY

Greeley, expect few human contacts. There are occasional pilgrims, however, and during the summer Bedouin herdsmen drive their sheep and goats up the mountain sides to take advantage of the scant pasturage around the high springs.

This is not the first time, it is probable, that the summit of Mount St. Katherine has been used as an astronomical observatory, of a sort. Arabs as early as the sixth century were conducting worship of the ancient moon god Sin on the summits of the Sinai mountains and may have set up one of their strange altars on the very site of the Smithsonian observatory.

Mr. Zodtner, in letters just received at the Smithsonian, reports that his family, consisting of his wife and two small children, is comfortably situated on the sacred mountain top except for the lonely desolation of the site. He already has started to make observations, observing on 15 days in January and 21 days in February with nearly cloudless skies.

Mount St. Katherine was selected as the site for the observatory after a long search over Africa and Asia for the highest, driest accessible spot in the eastern hemisphere where low wind velocities prevail. It represented the best combination of these conditions that could be found. For years the Astrophysical Observatory of the Smithsonian, under the direction of Dr. Abbot, has been measuring daily the amount of solar radiation in different parts of the western hemisphere—at Washington, Table Mountain in California and Mount Montezuma, Chile. This patient work is beginning to lead to important conclusions concerning variations in the earth's weather, and progress has been especially rapid during the past year.

But reliable data from the eastern hemisphere are desirable in order to multiply the chances of observing the sun's heat every day without breaks. For the sun is a slightly variable star. Its variations can not be accurately predicted. Daily observations are required to make complete the investigation of relations of weather to the sun's heat. It is to secure such data that Mr. Zodtner has set up his instruments on Mount St. Katherine.

Few spots on earth approach the ideal for these delicate measurements. What is measured is the amount of heat from the sun that falls at any given time on a hypothetical black object with the dimensions of a cubic centimeter, placed at the edge of the earth's atmosphere. Nobody, of course, can get to the edge of the atmosphere to place and observe such a cube. It must be an imaginary cube, with the amount of heat it absorbs measured somewhere on the earth's surface. The radiation that actually comes through to the surface is far different in amount from that which would be received by the hypothetical black body, because of the very great complications brought about by the content of the atmosphere itself.

First of all, there must be a completely cloudless sky. Secondly, the air is full of water. Water absorbs radiation, especially at the lower edge of the spectrum from the limits of the visible red far into the invisible infra-red. So it is essential to find a mountain in a desert where the water vapor will be at a minimum.

Thirdly, the minute dust particles in the atmosphere scatter the radiation over the sky. So there must be a minimum of dust. Fourthly, the delicacy of the measurements requires nearly calm winds in order to observe with the accuracy demanded. Mount St. Katherine comes close to satisfying all these conditions.

ELEMENT NUMBER 93

HAS a super-uranium, the first of a series of elements heavier than the recognized 92 chemical building blocks, been discovered? Dr. Enrico Fermi, 32-year-old physicist of the Royal University of Rome, by atomic bombardment has reported that he can artificially create a new element, No. 93. He obtained this result by bombarding uranium, heaviest of elements, with neutrons.

Uranium is the heaviest element found in nature, being 238 times as dense as hydrogen, the lightest. For many years it was thought to be the limit of all the possible elements, but recently Sir Arthur Eddington and other theoretical scientists have calculated the maximum number of possible elements as 136. Element No. 93 of Dr. Fermi, if its reality is substantiated by competent investigators working independently, may be the first of the super-heavy substances lying beyond uranium in the gamut of chemical elements.

Opinion among American physicists regarding Dr. Fermi's discovery indicates that if still-heavier elements are found they will be transitory substances breaking down like the naturally radioactive elements such as radium but probably much faster. For the provisional element No. 93 it is reported to take only 13½ minutes for the initial quantity of the element to "decay" or disintegrate to half the amount.

By what proof Dr. Fermi bases his report on the actuality of element No. 93 is still unannounced. In his recent communication to the British scientific journal, *Nature*, however, he cites twenty-three cases where he had been able to produce artificial radioactivity in a variety of elements with the same apparatus he employed for creating element No. 93. In recounting his work Dr. Fermi told of observing electrons being given off as the man-made radioactive substances decayed away. Thus he differed with the earlier research of Irene Curie and Professor F. Joliot of Paris, who have observed positrons being omitted in the process.

The atomic happenings which might account for the creation of the new element out of uranium are still a subject of debate and conjecture among scientists. One possible occurrence might be that the neutrons used by Dr. Fermi (consisting, if they do, of a positive particle, the proton and a negative charge, the electron) might break into two parts on impact with the nucleus of the uranium atoms. The proton might embed itself within the uranium nucleus and so increase the weight of the atom to No. 93, while the electron part of the neutron would be given off in the process and be detectable either with electrical instruments known as Geiger counters or by photographing the electron tracks in a Wilson cloud chamber.

The best way to determine whether the new element No. 93 really exists would be to weigh it on the atomic "scales"—the mass spectrograph. It does not appear that this crucial test has been applied in Dr. Fermi's work, for no mention was made of the method.

What amazes American scientists regarding Dr. Fermi's experiments is that his source of bombarding neutrons is comparatively weak. In a small glass tube the Italian scientist placed beryllium and the radioactive gas, radon, given off by radium as it breaks up. The action of the radon on the beryllium caused swift-moving neutrons to come off which struck a nearby bit of uranium. About 100,000 neutrons were liberated in this fashion each second. In America sources of neutrons have been developed which are capable of giving off 100 times this number per second.

It is only since the beginning of 1934 that the technique of creating artificial radioactivity in normally stable elements

has been known to the world of science. On January 31 Irene Curie (daughter of the late Madame Curie, discoverer of radium) and her husband, M. F. Joliot, announced that by bombarding the elements boron, magnesium and aluminum with the heavy cores of helium atoms they were able to create transitory radioactive forms of nitrogen, silicon and phosphorus.

Substantiation of the Curie-Joliot experiments followed swiftly from the Cavendish Laboratory at the University of Cambridge, England, and from the California Institute of Technology and the University of California in America. In England the favorite atomic bombarding particles have been the cores of hydrogen atoms—the protons. In the California experiments the cores of the new heavy hydrogen—the deutons—have been driven at a variety of elements to produce artificial radioactivity.

Work prior to that of Dr. Fermi on the creation of artificial radioactivity has all been accomplished by using relatively light-weight elements as targets. That the same phenomena could be produced in the heaviest and most complicated atom of all, uranium, was unknown. For uranium, and the whole series of elemental offspring which finally ends when lead is reached, it was known that natural radioactivity was occurring with elements gradually turning into substances of slightly less weight. Many experiments seemed to indicate that nothing man could do would change the rate at which the natural disintegration occurred, either to slow it down or speed it up. If Dr. Fermi's work on the creation of element No. 93 is substantiated later by other scientists it will be the first case where the hitherto impregnable sequence of natural radioactivity change has been altered.

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